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An Analysis of Nutrients Intake, Related Factors of Anemia and Bone Density in Ballet Dancers

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Abstract

The subjects of this study were 18 non-diseased Professional Ballet Dancers(PBD) and 13 non-diseased Student Ballet Dancers(SBD). For the test, diet recording methods were used to analyze nutrients intake. Blood samples were collected from the antecubital vein to analyze related factors of anemia (iron, hematocrit, hemoglobin and platelet) and bone density (calcium, phosphorus, vitamin D, parathyroidhormone andCa^{2+}/Pi ratio). Independent *t*-tests and Pearson's correlations methods were both used for statistical analyses.In related factors of anemia, iron in PBD was significantly lower than in SBD. In related factors of bone density,vitamin D in PBD was significantly higher than in SBD. There were significant positive correlations between vitamin A and iron, betweenvitamin B6 and iron, as well as between phosphorus and plant lipid. There were also significant inverse correlations between vitamin B2 and platelet, between plant lipid and hematocrit, as well as between plant lipid and platelet.

Keywords: Anemia, Ballet Dancer, Bone Density, Nutrient Intake

1. Introduction

Ballet is an art form that has entranced people worldwide for hundreds of years. The ethereal beauty and grace of an excellent ballet dancer, however, is achieved only through many hours of strenuous practice each day, often resulting in female athlete triad. Female ballet dancers have unique stresses on their training, eating attitudes, and bodyweight. In addition, some ballet dancers have osteopenia, eating disorders, and abnormal menstruation cycles.Iron, a mineral found in foodthat is essential in keeping the body healthy, is especially necessary for ballet dancers to meet their maximum energy and peak performance.Therefore, dancers who have a marginal or inadequate iron intake can weaken their exercise performance by decreasing the amount of oxygen delivered to the muscles, which impairs muscle contractions and strength[1].

People at risk from developing iron deficiency anemia include children less than two years of age, infants, teenage girls, pregnant women, pre-menopausal women, the elderly, vegetarians, and female endurance athletes. A poor dietary intake and increased loss of irons from menstruation are primary reasons for the development of a deficiency. Menstruating females require almost twice as much iron as their male counterparts in order to replace monthly losses[1]. Several investigations have shown that female athletes have a greater prevalence of iron deficiency compared to sedentary individuals[2–6]. However, others have shown that the prevalence of iron deficiency is no greater in trained individuals than in the general population[7,8].

Participation in various physical activities is associated with positive effects on bone mineral accrual[9–11].However, participants in physical activities thatemphasizean aesthetic build and a low body weights havebeen identified as being potentially at risk for developingthesyndrome[12].Given that dancing is an artistic expression in which physical aesthetic and fitness

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are key elements of performance[13], dancers can also fall into the at risk category. Indeed, observational data has suggested that intense dance training during growing years, combined with low energy intake and low body weight, might cause menstrual dysfunctions and skeletal muscle weakness[14]. Moreover, professional ballet dancers have been consistently found to have low Bone Mineral Density (BMD)[15–18].

Therefore, this study will analyze the nutrients intake and anemia-related factors of bone density on ballet dancers. This will provide the basic data for the development of a health improvement program on ballet of future dancers.

2. Material and Methods

2.1 Subjects

The subjects of this study are 31 female ballet dancers, including professionals and students, who applied and agreed to the intent and contents of the research and who have no special disease as determined by a basic health check-up. The physical characteristics of the subjects are given in Table 1.

Table 1. Physical characteristics of subjects

Item Group	Age (yrs)	Weight (kg)	Height (cm)	BMI (kg/m²)	Career (yrs)
PBD (n=18)	26.83 ±3.4	48.08 ±4.03	164.66 ±3.26	17.71 ±1.15	12.41 ±5.75
SBD (n=13)	21.15 ±4.21	49.5 ±3.89	163.62 ±3.32	18.47 ±1.14	6.87 ±3.32

Values are means ±SEM, PBD; Professional Ballet Dancers, SBD; Student Ballet Dancers

2.2 Experimental Procedure and Design

After body weight and height were determined (Inbody 720, BioSpace Co., Korea), all subjects filled out a nutrients intake used by the diet recording method (CANPro 4.0, The Korean Nutrition Society, 2010). In addition, 10mL blood samples of Professional Ballet Dancers (PBD) and Student Ballet Dancers (SBD) were collected from the antecubital vein. Anemia-related factors were estimated by measure of iron, hematocrit, hemoglobin, and platelet, and bone densitywas evaluated by calcium, phosphorus, vitamin D, parathyroid hormone and Ca^{2+}/Pi ratio.

2.3 Blood Collection and Analysis

A blood was drained from the median cubital in the morning, after 8hours of fasting. A total of 10 mL of blood was extracted during each blood collection. The collected blood storedbetween -80 and -70 °C after serum separation, following 5-minute centrifugation at 3,000 rpm. The stored blood was sent to a clinical center for analysis. Iron, hematocrit, hemoglobin, and platelet were analyzed by Mod CELL-DYN (Abbott Co., USA). Calcium was analyzed by Arsenazo III method, and phosphorus was analyzed by colorimetric method using AVIA 2400 (Siemens, U.S.A.).Vitamin D was analyzed by Chemiluminescent Immunoassay-method (CLIA), and parathyroid hormone was analyzed by Electrochemiluminescent Immunoassay-method (CELIA).

2.4 Statistical Analysis

The measured value of this study was calculated by mean and standard deviation using Statistical Package for the Social Sciences (SPSS)Ver. 21.0. The differences between ballet dancers were tested by t-test. The correlation among variables was tested by Pearson's correlation analysis, and .05 is the significance level.

3. Results

Table 2. Related factors of anemia

Item	Group	M± SD	t	p
Fe^{2+}(g/dl)	PBD(n=18)	75.48±47.88	-2.021	0.036
	SBD(n=13)	120.77±60.87		
Hct(%)	PBD(n=18)	40.56±2.83	-0.732	0.472
	SBD(n=13)	41.46±3.76		
Hb(g/dl)	PBD(n=18)	13.09±1.10	-2.23	0.053
	SBD(n=13)	13.87±1.03		
Platelet	PBD(n=18)	280.00±43.55	-1.079	0.290
(×10³/μ)	SBD(n=13)	296.85±42.40		

Values are means ±SEM, Fe; Iron, Hct; Hematocrit, Hb; Hemoglobin

Tables 2 and 3 show the result of anemia-related factors and bone density-related factors, respectively. An anemia-related factor, such as iron, shows lower levels in PBD than in SBD (p<.05). In addition, hematocrit, hemoglobin, and platelet show lower levels in PBD in SBD, but did not show a significant difference according to the ballet dancers. However, vitamin D shows higher levels in PBD than in SBD (p<.05). Bone density-related factors such as calcium, phosphorus and parathyroid hormone show lower in PBD than SBD, but did not show a significant difference according to the ballet dancers.

Table 3. Related factors of bone density

Item	Group	M±SD	t	p
Ca^{2+}(mg/dl)	PBD(n=18)	9.36±0.52	-0.198	0.843
	SBD(n=13)	9.40±0.55		
Pi(mg/dl)	PBD(n=18)	3.96±0.43	-396	0.369
	SBD(n=13)	4.09±0.39		
Ca/Piratio (%)	PBD(n=18)	2.39±0.30	0.862	0.396
	SBD(n=13)	2.31±0.20		
Vit D(mg/dl)	PBD(n=18)	36.02±9.43	2.679	0.012
	SBD(n=13)	27.57±7.44		
PTH(mg/dl)	PBD(n=18)	15.68±13.00	-0.230	0.820
	SBD(n=13)	16.87±15.72		

Values are means ±SEM, Ca; Calcium, Pi; Phosphorus, Vit D; Vitamin D, PTH; Parathyroid Hormone.

3.1 Pearson's Correlations between Nutrients Intake and Related Factors Anemia

Tables 4 and 5 illustrate the correlation between nutrients intake and anemia-related factors, as well as between nutrients intake and bone density-related factors for ballet dancers. In the analysis, there is a significant correlation between nutrients intake, anemia-related factors, as well as between nutrients intake and bone density ($p<.05$). Moreover, there is a significant inverse correlation between plant lipid and hematocrit, as well as between plant lipids, vitamin B2, and platelet ($p<.05$).

3.2 Correlation Coefficient between Nutrients Intake and Related Factors Bone Density

Table 4. Correlation coefficient between nutrients intake and anemia

	Fe	Hct	Hb	Pla	PP	AP	PL	AL	Vit A	Vit B1	Vit B2	Vit B6	Vit C	Vit E	FA
Fe	1														
Hct	0.393*	1													
Hb	0.490**	0.897**	1												
Pla	-0.023	0.134	0.045	1											
PP	0.253	-0.069	0.000	-0.134	1										
AP	0.103	0.117	0.085	-0.314	0.583**	1									
PL	0.074	-0.366*	-0.257	-0.382*	0.430*	0.251	1								
AL	0.343	0.040	0.036	-0.329	0.089	0.215**	0.038	1							
Vit A	0.483**	0.088	0.192	-0.246	0.398*	0.364*	0.237	0.728**	1						
Vit B1	0.278	0.120	0.147	-0.321	0.677**	0.482**	0.238	0.477**	0.666**	1					
Vit B2	0.132	0.236	0.156	-0.381*	0.387*	0.420*,**	0.074	0.564**	0.557**	0.836**	1				
Vit B6	0.444*	0.361*	0.280	0.042	0.215	0.443*,**	-0.188	0.520**	0.680**	0.432*	0.429*	1			
Vit C	0.239	0.111	0.128	-0.054	0.448*	0.050	0.257	0.145	0.315	0.387*	0.250	0.248	1		
Vit E	0.186	0.155	0.155	-0.086	0.192	0.506*,**	0.231	0.443*	0.476**	0.153	0.232	0.445*	0.211	1	
FA	0.335	0.219	0.159	-0.078	0.455*	.349*	0.070	0.545**	.804**	0.628**	0.582**	0.777**	0.603**	0.503**	1

Fe; Iron, Hct; hematocrit, Hb;Hemoglobin, Pla; Platelet, PP; Plant Protein, AP; Animal Protein, PL; Plant Lipid, AL; Animal Lipid, VitA; Vitamin A, VitB1; Vitamin B1, VitB2; Vitamin B2, VitB6; Vitamin B6, VitC; Vitamin C, VitE; Vitamin E, FA; Folic Acid, *; Significantly different among variables ($p<.05$),**; Significantly different among variables ($p<.01$).

4. Discussion

Iron has several important functions within the body. It is needed to form an important part of red blood cells called hemoglobin, which transports oxygen from the lungs to the rest of the body. It also forms part of a muscle protein called myoglobin, which provides oxygen to the muscles during strenuous physical activity. Iron can also strengthen the immune system of the body, increasing resistance to colds, infections, and disease[1].

Other concerns for a compromised iron status in athletes relate to both dietary and physiological mechanisms such as insufficient iron intake[3,19], iron loss through sweat[20], occult blood loss from the gut[21], hemoglobinuria, hematuria[22,23], and hemolysis[24–26]. Haymes[27] suggested that depleted iron stores in female athletes are likely to relate a low dietary intake of iron. The Recommended Dietary Allowance (RDA) for iron is 15 mg/day for women.

The present study showed that Fe ($p=.036$) in

Table 5. Correlations between nutrients intake and related factors bone density

	Ca	Pi	Vit D	PTH	PP	AP	PL	AL	Vit A	Vit B1	Vit B2	Vit B6	Vit C	Vit E
Ca	1													
Pi	0.100	1												
VITD	-0.245	0.216	1											
PTH	0.231	0.102	-0.130	1										
PP	0.354	0.120	-0.195	0.183	1									
AP	0.180	0.139	0.046	-0.020	0.583**	1*								
PL	0.306	0.370*	-0.245	-0.083	0.430*	0.251	1							
AL	0.119	0.062	-0.071	0.003	0.089	0.215**	0.038	1						
Vit A	0.313	0.023	-0.113	0.012	0.398*	0.364*	0.237	0.728**	1					
Vit B1	0.308	-0.035	-0.084	0.191	0.677**	0.482**	0.238	0.477**	0.666**	1				
Vit B2	0.093	-0.012	0.198	0.192	0.387*	0.420*,**	0.074	0.564**	0.557**	0.836**	1			
Vit B6	0.080	-0.020	0.191	0.002	0.215	0.443*,**	-0.188	0.520**	0.680**	0.432*	0.429*	1		
Vit C	0.151	-0.080	-0.008	0.191	0.448*	0.050	0.257	0.145	0.315	0.387*	0.250	0.248	1	
Vit E	-0.004	0.204	0.123	-0.268	0.192	0.506*,**	0.231	0.443*	0.476**	0.153	0.232	0.445*	0.211	1

Ca; Calcium, Pi; Phosphorus, Vit D; Vitamin D, PTH; Parathyroid Hormone, PP; Plant Protein, AP; Animal Protein, PL; Plant Lipid, AL; Animal Lipid, VitA; Vitamin A, VitB1; Vitamin B1, VitB2; Vitamin B2, VitB6; Vitamin B6, VitC; Vitamin C, VitE; Vitamin E, *; Significantly different among variables (p<.05),**; Significantly different among variables (p<.01).

PBD was significantly lower than in SBD. Hematocrit, hemoglobin, and platelet in PBD were lower than in SBD ostensibly without significance. A lack of iron can leave one tired, run-down, and prone to infections. As the condition worsens, symptoms that are more dramatic may develop, such as cramps, headaches, severe fatigue, shortness of breath, poor stamina, and/orsensitivity to cold temperatures[1].

Contrary to popular belief, vegetarians, along with others who consume minimal amounts of red meats,canobtain sufficient iron from their food with the help of vitamin C, which can enhance the body's uptake of iron. Vitamin C reacts with 'non-haem' iron, making it easier for the body to absorb.Forexample,eating grain cereal, drinking a glass of orange juice at breakfast, or adding a tomato or capsicum to a legume/vegetable stir-fry fordinner can all increase iron levels[1].

Vitamin D, the vitamin manufactured in the presence of iron, is an importance nutrient for brain development, tissue differentiation,glucose homeostasis, thecardiovascular andimmune systems, as well as muscle function in children and adults[27–30]. In general, indooratheletes, such as ballet dancers, face an increased risk of vitamin D insufficiency[32]. The lack of sun exposure and low dietary intake of vitamin D have both been shown to be significant predictors of vitamin D levels in both males and females[33–38]. Furthermore, vitamin D regulates calcium levels in the body[39]. Thus, an insufficiency could be detrimental to the growing skeleton. If bone density loss continues in young ballet dancers, it may place them at high risk for musculoskeletal injuries during their career (such as stress fractures) and osteoporotic fractures later in life[32].

The present study indicated that vitamin D (p=.012) in PBD was significantly higher than in SBD. Ca^{2+}, Pi, and PTH in PBD are lower than in SBD but with no real significance. The Ca^{2+}/Pi ratio in PBD was higher than in SBE but also with no significance.The lack of sunexposure and low vitamin D intakeof ballet dancers increases risk factors, like musculoskeletal health[32].

Across-sectional study of 166 female adolescents, including 54 ballet dancers, demonstrates that one hour of physical activity per week has a high correlation with BMD. In particular, in the case of young women showing the lowest level (25-OHD < 28 mmol/mL), it is reported that bone density appears to be in higher correlation[40].

In this research, anemia-related factors (iron, hematocrit, hemoglobin, andplatelet) and bone density-related factors (calcium, phosphorus, vitamin D, parathyroid hormone and Ca^{2+}/Pi ratio) are very low compared with the average range. The related factors of anemia and bone density may decrease from both limited diets and excessive dance performance. Therefore, it is important to maintain balanced nutrition and gain appropriate education.

Vitamins in daily life are very important, especially to sustain health. They are necessary for coenzymes to produce antioxidants, metabolize protein (vitamin Bs), produce energy reactions (thiamine, riboflavin, niacin, and pantothenic acid), maintain calcium levels (vitamin

D), synthesize new cells (folacin and vitamin B), and protect the integrity of cell membranes (vitamin E). Some vitamins, such as thiamine, riboflavin, and niacin, have essential roles in energy production[41].

Correlation analyses between the related factors of nutrition and anemia support the importance of both plant and animal protein intake. Hemoglobin is closely relatedto Fe^{2+} as well as hematocrit; both are ingested through food that is rich in vitamin A and vitamin B6, respectively. In general, vitamin B1, B2, B6, and vitamin E are all associated with important nutrients. Specifically, there are positive correlations between folic acid and nutrients such as vitamin A, B1, B2, B6, C, and E, plant protein, animal protein, and animal lipid. Thus, it is recommended to consume green vegetables to help prevent anemia.

In general, the vitamin intake of adult athletes was found to meet the RDA for most vitamins. There were some exceptions, however. The vitamin intake of many adolescent girls involved in ballet and gymnastics is low in comparison to the RDA[42–44]. In particular, many girls had dietary intakes of vitamins E, B, and folate that were less than 213 of the RDA for these vitamins[42,43]. Welch and colleagues[45] found that the majority of college women athletes they studied were consuming diets deficient in vitamin B, and folate. In 1989, the RDA for folacin was lowered from 400 ug to 180 ug. Using the 1989 RDA, the proportion of female athletes with diets low in folacin reduces considerably[41].

Severe deprivation of folate and vitamin B12 reduces endurance work performance and results in anemia. Evidence of vitamin A and E deficiencies in athletic individuals is lacking because body storage is appreciable. In contrast to vitamins, marginal mineral deficiencies impair performance. Iron deficiency, with or without anemia, impairs muscle function and limits work capacity[46].

Correlation analyses between the related factors of nutrition and bone densityindicated that phosphorus can be absorbed through the plant lipid. Plant protein and animal lipids are associated with a variety of vitamins. Therefore, it is considered helpful to intake supplements or food high in vitamins.

5. Conclusion

The results indicate that related factors of anemia and bone density for all subjects were within the normal range. However, if the subjects maintained their current diet and physical activity, their bone density would lower; thus, they should consider their bone density status in the future. To reach maximum bone mineral status, the subjects should decrease salt intake and increase levels of calcium, phosphorus, vitamin D and PTH. In order to prevent anemia, they need increased intake of Fe^{2+}. Moreover, it is thought that education and profound study on relevant factors affecting the genesis of bone density is desirable. It would be advised for athletes to participate in various education programs regularly in order to improve health knowledge and practices.

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