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Vitamin D Intake and Sun Exposure Among Malaysian Athletes in National Sports Institute, Bukit Jalil

[1]LW Leong, [1, 2]SP Loh* & [3]A Neng Azhanie

[1]Department of Nutrition and Dietetics, Faculty of Medicine and Health Sciences
Universiti Putra Malaysia, Serdang, Selangor, Malaysia
[2]Institute of Bioscience, Universiti Putra Malaysia, Serdang, Selangor, Malaysia
[3]Sports Nutrition Centre, National Sports Institute, Bukit Jalil, Selangor, Malaysia

ABSTRACT

Introduction: Vitamin D plays an important role in maintaining the physical health as well as the performance of athletes. This cross-sectional analytical study was conducted to determine vitamin D intake, sun exposure and skin types of both indoor and outdoor Malaysian athletes in the National Sports Institute, Bukit Jalil. **Method:** A total of 28 indoor (badminton, shooting, wushu and fencing) and 36 outdoor (athletics, football and hockey) athletes were recruited for this study. The dietary vitamin D intake was estimated using Vitamin D-specific Food Frequency Questionnaire (FFQ). The Sun Exposure Index (SEI) was calculated from Seven-day Sun Exposure Record while the skin types of athletes were determined using Fitzpatrick Skin Typing Questionnaire. **Results:** The mean age of the athletes was 21.02±4.11 years and their mean Body Mass Index (BMI) was 22.20±2.22 kg/m^2. The mean body fat percentage of outdoor athletes was significantly lower than indoor athletes ($p<0.001$). Forty two athletes (65.6%) met the recommended nutrient intake (RNI) value for vitamin D and the outdoor athletes had significantly greater amount of vitamin D intake compared to RNI ($p<0.05$) and the indoor athletes ($p<0.05$). The indoor athletes spent significantly less time outdoor per day ($p<0.05$) and had lower SEI per day ($p<0.05$) than outdoor athletes. Most of the indoor athletes (53.6%) had type II of Fitzpatrick skin type while the outdoor athletes (47.2%) had type III of Fitzpatrick skin type. **Conclusion:** The outdoor athletes had higher intake of vitamin D and more sun exposure than indoor athletes. There is a need to ensure the adequacy intake of vitamin D among indoor athletes.

Keywords: Vitamin D intake, sun exposure, Fitzpatrick skin type, atheletes

INTRODUCTION

Vitamin D, which is also known as sunshine vitamin, is the most accessible vitamin in our daily life especially in tropical countries like Malaysia. Vitamin D can be synthesized endogenously when the skin is exposed to ultraviolet B (UVB) radiation (wavelength range of 290-315nm).[1] However, the problem of low vitamin D status was found in the countries with abundant sunshine, where high amounts of sun exposure do not ensure the adequacy of vitamin D.[2, 3] There are various factors that may limit or inhibit the amount of sun exposure and the synthesized of vitamin D. Aging, skin pigmentation, sunscreen use, clothing, cloud cover, atmospheric pollution, time of day, indoor activity, geographic location are examples of factors that can impair vitamin D synthesis.[4] Vitamin D can be obtained from diet oily fish (such as salmon, mackerel and sardine), fish oil (such as cod liver oil), egg yolks and food fortified with vitamin D (such as fortified milk, margarine and cereal products) are good sources of dietary vitamin D.[5]

Vitamin D is important for the development and maintenance of bone as well as for the maintenance of normal calcium and phosphorus homeostasis.[6] Recent studies have revealed the roles of vitamin D in cancer prevention[7], reducing the risk for diabetes mellitus and promoting body's autoimmunity[8], cardiovascular diseases and osteoporosis prevention[9] as well as improving athletes' performance.[4]

In athletes, vitamin D plays major role in maintaining their physical health and performance. Active individuals required sufficient vitamin D for the bone health and bone injury prevention..[10] The risk of stress fracture which is common among athletes is significantly increased when serum 25(OH)D, an indicator of vitamin D status, is defined as insufficient.[4] Moreover, the study by Halliday *et al*. (2011)[11] in college athletes also demonstrated the positive association between vitamin D status and the frequency of documented illness. Although there is no evidence to show the direct relationship between vitamin D status and athlete's performance, vitamin D inadequacy in athletes can hamper their performance, indirectly since their health could become poor due to insufficient vitamin D.

Vitamin D is the micronutrient which is normally ignored in sport nutrition even though it can hamper or promote

*Corresponding author: *sploh@medic.upm.edu.my*

the performance of athletes.[1] The aim of this study was to determine the intake vitamin D and sun exposure among athletes in Malaysia is currently no data is available in this country.

METHODOLOGY

Subjects

All Malaysian male and female athletes from National Sports Institute aged between 18 years and above were invited to participate in the study which was approved by the Medical Research Ethics Committee of the Faculty of Medicine and Health Sciences, Universiti Putra Malaysia. The inclusion criteria for subjects' recruitment were male and female, aged 18 and above. Moreover, the subjects had to be Malaysians since this study aim is to determine the vitamin D intake and sun exposure among Malaysian athletes. The information sheets and consent forms were given out before data collection so that the participants could have a brief understanding of the study. The subjects were classified as either indoor- or outdoor-based athletes depending on their sport. In this study, the indoor athletes were defined as those who trained and competed indoor while the outdoor athletes are those who trained and/or competed outdoor.

Study design & sampling method

This was a cross-sectional analytical study, which was conducted at a single point in time. Convenience sampling method was used to recruit subjects due to availability and accessibility of subjects during the time of data collection. although the recuited sample might not be representative, this was the sampling method which could reach the targeted number of subjects in the limited duration and the most feasible method for this study.

Sample size

Since the comparison of vitamin D and sun exposure between indoor and outdoor athletes is involved, comparing two population means was used in determining the sample size for each group as shown below[12]:

$$n_i = 2\left(\frac{z_{1-\alpha/2} + z_{1-\beta/2}}{ES}\right)^2$$

Where $\alpha = 0.05$, $\beta = 0.8$ and $ES = \frac{|\mu_2 - \mu_2|}{\sigma}$

However, since data for is not available, we used $S_p = \sqrt{\frac{(n_1-1)\, s_1^2 + (n_2-1)\, s_2^2}{n_1 + n_2 - 2}}$ to calculate the value for σ. Study by Halliday *et al* 2011[11] that showed significant difference between vitamin D status of indoor (n=12, 39.9 ± 8.9 ng/ml) and outdoor (n=29, 53.1± 17.4 ng/ml) athletes was used for the calculation.

$$S_p = \sqrt{\frac{(12-1)\,(8.9)^2 + (29-1)\,(17.4)^2}{12 + 29 - 2}}$$

$$= 15.48$$

So,

$$ES = \frac{|\,39.9 - 53.1\,|}{15.48} = 0.85$$

With the above value of ES, the number of subjects in each group was computed as below:

$$n_i = 2\left(\frac{z_{1-\alpha/2} + z_{1-\beta/2}}{ES}\right)^2 = 2\left(\frac{1.96 + 0.84}{0.85}\right)^2 = 21.7$$

According to the formula, the calculated sample size for each group was 22 persons. Thus, the total sample size required for this study was 44 persons. However, to overcome the problem of incomplete questionnaires, more subjects have to be recruited to allow for attrition. Assuming that 20% of the subjects failed to complete the questionnaires, a total number of 56 subjects were needed (28 subjects per group) for this study.

Instruments

A brief socio-demographic background of the subjects was recorded including body weight and height as well as body fat percentage using a self-administered bilingual (Bahasa Malaysia and English) questionnaire.

The dietary vitamin D was estimated by using Vitamin D-specific Food Frequency Questionnaire (FFQ) from Wu *et al*. (2009)[13] which consists of a list of 35 specific food items known as source of dietary vitamin D. The list of food items had been modified according to the food available in the country. Subjects were required to recall the frequency of food and supplements that were consumed for the past one month. The average of the vitamin D daily intake was calculated by expressing the response to the food item as a portion of daily use, which was then multiplied by the amounts of the specified portion sizes and by the vitamin D content of the food. The values of vitamin D content in food were obtained from the food labels and food databases of USDA and New Zealand.

The Sun Exposure Index (SEI) was calculated from Seven-day Sun Exposure Record.[14] Subjects were requested to record total minutes spent outdoor for each period from 7am-7pm as well as the clothing, sunscreen use and outdoor activity for those minutes. Body surface area (BSA) exposed was estimated referring to the guidelines of clothing key. Minutes and SEI are used to estimate the sun exposure where SEI is the product of time spent outdoor and BSA exposed. The average SEI, where the total SEI is divided by total minutes, was calculated for each subject using this record.

Fitzpatrick Skin Typing Questionnaire was used to determine the skin type of subjects. The Fitzpatrick skin phototypes were developed by Thomas B. Fitzpatrick in 1975 based on an individual's skin colour and responses to sun exposure in terms of degree of burning and tanning.[15] There are three components in this questionnaire including genetic disposition, reaction to sun exposure and tanning habits. A scale of zero to four is used to measure the response to each question. The total score, summation of score for all questions, is used to classify the skin type corresponding to Fitzpatrick skin type.

Data analysis

The collected data was analyzed using the SPSS version 17.0. The descriptive data such as mean age, height and weight, types of sport, skin types, minutes spent outdoor, SEI per day and daily vitamin D intake were used to describe the characteristics of the subjects. On the other hand, single sample t-test was used to test the significant difference between vitamin D intake and RNI for vitamin D (5μg) among athletes. Independent or unpaired samples t-test was used to test the significant differences in vitamin D intake and sun exposure between indoor and outdoor athletes.

RESULTS

Socio-demographic background

Initially in total, 80 athletes volunteered to participate in the study, however, 16 of them were excluded in the analysis due to incomplete data and for not fulfilling the indoor or outdoor athletes classification of subject recruitment. Hence, the study sample size was 64 athletes, which consisting of 28 indoor and 36 outdoor athletes. The socio-demographic characteristics of the subjects are shown in Table 1.

Table 1. Socio-demographic characteristics of subjects

Characteristics		Indoor (n=28)	Outdoor (n=36)	Total (n= 64)
		n (%)	n (%)	n (%)
Sex	Male	16 (57.1%)	32 (88.9%)	48 (75.0%)
	Female	12 (42.9%)	4 (11.1%)	16 (25.0%)
Ethnicity	Malay	10 (35.7%)	33 (91.7%)	43 (67.2%)
	Chinese	17 (60.7%)	0 (0.0%)	17(26.6%)
	Indian	-	3 (8.3%)	3 (4.7%)
	Other	1 (3.6%)	-	1 (1.6%)
Status	Elite	11 (39.3%)	4 (11.1%)	15 (23.4%)
	Back-up	17 (60.7%)	32 (88.9%)	49 (76.6%)
Accommodation	Hostel	25 (89.3%)	28 (77.8%)	53 (82.8%)
	Home	-	7 (19.4%)	7 (10.9%)
	Other	3 (10.7%)	1 (2.8%)	4 (6.3%)
Type of sports	Badminton	6 (21.4%)	-	6 (9.4%)
	Shooting	9 (32.1%)	-	9 (14.1%)
	Wushu	9 (32.1%)	-	9 (14.1%)
	Fencing	4 (14.3%)	-	4 (6.3%)
	Athletics	-	13 (36.1%)	13 (20.3%)
	Football	-	19 (52.8%)	19 (29.7%)
	Hockey	-	4 (11.1%)	4 (6.3%)
Age (mean ± SD)*		23.11 ± 4.89	19.39 ± 2.41	21.02 ± 4.11

*significant differences between indoor & outdoor groups at level $p<0.001$

Table 2. Anthropometric measurements and body fat percentage of subjects

Measurements	Indoor (n=28)	Outdoor (n=36)	Total (n=64)
	mean ± SD	mean ± SD	mean ± SD
Height, cm*	166.34 ± 7.77	171.85 ± 8.28	169.44 ± 8.46
Weight, kg	61.42 ± 9.31	65.99 ± 9.78	63.99 ± 9.77
BMI, kg/m2	22.14 ± 2.60	22.24 ± 1.91	22.20 ± 2.22
Body fat percentage**	22.15 ± 6.11	15.60 ± 3.77	18.47 ± 5.89

Significant differences between indoor & outdoor groups (*$p<0.05$, **$p<0.001$)

As shown in Table 2, the mean height of subjects was 169.44 ± 8.46 cm with the mean height of outdoor athletes significantly higher than indoor athletes ($p<0.05$). The average weight of subjects was 63.99 ± 9.77 kg. The average weight of outdoor athletes was greater than indoor athletes as well. However, similar BMI was found between indoor and outdoor athletes groups with the mean BMI of subjects at 22.20 ± 2.22 kg/m^2. For body fat percentage, the average reading for all subjects was 18.47 ± 5.89. The indoor athletes was having significantly greater percentage of body fat than the outdoor athletes ($p<0.001$).

According to the BMI classifications by WHO (2004)[16] the majority of the subjects were normal in their BMI classification (92.2%). One subject from the indoor group was classified as underweight (1.6%) and four subjects were categorized as overweight (6.3%), which comprised two athletes from each group.

Since athletes are physically active, it might be more suitable and meaningful to describe the body composition of athletes instead of BMI. The body fat percentage of the subjects was classified according to ratings of body-fat percentage levels for males and females aged 18-30.[17] Most of the subjects were in the range of good (31.3%) and acceptable (53.1%). Five of them were rated with athletic category, which usually applies particularly to athletes who compete in events where excess body fat may be a disadvantage. On the other hand, five subjects were rated as overweight and obese. It was found that more indoor athletes were found to have greater body fat percentage. However, only a small number of athletes had excess body fat.

Vitamin D intake

The daily intake of vitamin D intake was calculated using data obtained from Vitamin D-specific FFQ and shown in Table 3. The mean daily vitamin D intake and intake from supplements of outdoor athletes was significantly higher than indoor athletes ($p<0.05$). The significant difference in total vitamin D intake between these two groups could be explained by the significant difference in supplements consumption.

Table 3. Vitamin D intake of subjects

Daily intake (µg)	Indoor (n=28)	Outdoor (n=36)	Total (n=64)
	mean ± SD	mean ± SD	mean ± SD
Food	5.40 ± 4.44	6.66 ± 5.70	6.11 ± 5.18
Supplements*	1.70 ± 4.09	6.82 ± 8.43	4.58 ± 7.29
Total*	7.10 ± 6.86	13.47 ± 10.50	10.68 ± 9.57

*significant differences between indoor & outdoor groups at level $p<0.05$

The recommended vitamin D intake as stated in RNI is 5 µg per day for all age groups except the elderly.[18] There was a relatively high number of subjects (34.4%) who did not meet the recommended intake. Almost half of the indoor athletes (46.4%) and a quarter of the outdoor athletes (25.0%) failed to consume a sufficient amount of vitamin D. Significant difference between RNI and vitamin D intake of all subjects was found in one sample t-test ($p<0.001$). Moreover, the intake of outdoor athletes also showed a significantly higher intake compared with RNI ($p<0.05$). According to the list of food items in vitamin D-specific FFQ, fresh milk was the major source of vitamin D among subjects. Furthermore, UHT milk, sandwich bread, salmon and eggs also contributed to the vitamin D intake of the subjects.

Sun exposure

Sun exposure measurements of subjects included average minutes spent outdoor per day, percent body surface area (BSA) exposed per day, Sun Exposure Index (SEI) and SEI with sunscreen are shown in Table 4. These measurements are important in determining how much time and body surface area of a subject are exposed to sunlight, enabling the dermal synthesis to occur. The average minutes, percent BSA exposed were determined every day that a subject went outside and the average did not take into account days in which the subjects did not go outside.

Table 4. Sun exposure measurements of subjects

Measurements	Indoor (n=28)	Outdoor (n=36)	Total (n=64)
	mean ± SD	mean ± SD	mean ± SD
Minutes per day**	22.61 ± 13.49	195.51 ± 64.03	119.87 ± 99.14
BSA per day	28.25 ± 9.42	32.17 ± 6.90	30.45 ± 8.26
SEI per day**	639.78 ± 430.35	6119.63 ±1830.75	3722.20 ± 3073.86
SEI with sunscreen per day**	586.01 ± 397.01	5809.63 ± 1474.30	3524.29 ± 2845.46

**significant differences between indoor & outdoor groups at level $p<0.001$

The percent of BSA exposed was affected by the clothing and sunscreen use of subjects. The average percent BSA exposed of subjects was 30.45 ± 8.26 %, corresponded to the face, neck, arms and hands (t-shirt), legs (shorts near the knees) and feet (sandals) being exposed to the sun. The mean value of percent BSA exposed among indoor athletes was lower than outdoor athletes which could be due to the clothing of indoor athletes that covered more body surface area to minimize the sun exposure when they went outside.

There was no significant difference between average SEI and SEI with sunscreen among the subjects. This may be due to the small number of sunscreen users (n=10) in this sample. The mean of SEI with sunscreen in outdoor athletes was significantly higher than indoor athletes as well. This showed that, despite the usage of sunscreen, outdoor athletes tend to received more sun exposure than indoor athletes.

Types of activities and percent of time spent performing the outdoor activities were obtained from the sun exposure records besides sun exposure measurements and sunscreen use. Walking was the most frequent activity where indoor athletes spent the modest percent of their time (67.8%) when they were outside, followed by riding motorbike (13.5%), outdoor training (9.7%), hiking (4.7%), playing badminton (1.6%), washing car (1.2%), jogging (0.8%) and sitting (0.8%). For outdoor athletes, the majority of their time was spent on outdoor training (80.0%). They spent 10.7% of the time on walking, 5.0% on having a match and 1.8% on jogging.

Skin type

The skin type of a subject was relatively important in determining how much of Ultraviolet-B could reach into the skin for dermal synthesis process. Three subjects (4.7%) had skin type II, the skin type that burns easily and tans minimally with difficulty after a long exposure to thesun. The skin types of type III and IV had modest number among all subjects, twenty six persons (40.6%) for each type. Those with skin type III burn moderately as well as tan moderately and uniformly after being exposed to the sun for a long period of time. While the subjects with skin type IV were more likely to be burned minimally and tanned moderately and easily. The rest of the subjects (14.1%) had the skin type V, which rarely burns and tans easily. Table 5 also showed that overall outdoor athletes had darker skin than indoor athletes.

Table 5. Fitzpatrick skin type classification of subjects

Classification	Indoor (n=28)	Outdoor (n=36)	Total (n=64)
	n (%)	n (%)	n (%)
Type II	2 (7.1%)	1 (2.8%)	3 (4.7%)
Type III	15 (53.6%)	11 (30.6%)	26 (40.6%)
Type IV	9 (32.1%)	17 (47.2%)	26 (40.6%)
Type V	2 (7.1%)	7 (19.4%)	9 (14.1%)

Ethnicities (genetic disposition) do influence the skin types of subjects, in which indirectly related to the cutaneous synthesis of vitamin D with the same Sun Exposure Index (SEI) across ethnicities. Table 6 shows the classification of skin type according to ethnicity of subjects.

Table 6. Classification of skin type according to ethnicity of subjects

Ethnicity	Fitzpatrick skin type			
	Type II (n=3)	Type III (n=26)	Type IV (n=26)	Type V (n=9)
Malay	2 (66.7%)	13 (50.0%)	22 (84.6%)	6 (66.7%)
Chinese	1 (33.3%)	12 (46.2%)	2 (11.8%)	2 (22.2%)
Indian	0 (0.0%)	1 (3.8%)	1 (3.8%)	1 (11.1%)
Others	0 (0.0%)	0 (0.0%)	1 (3.8%)	0 (0.0%)

DISCUSSION

The surprising finding of this study was that vitamin D intake was significantly different between indoor and outdoor groups. It was believed that the type of sports do not differ them in terms of vitamin D intake from food and supplements. The differences occurred may be due to cultures and ethnicities of subjects which shaped them with different food habits or supplement use.[14] Moreover, taste preference, familiarity and religion do affect the food choices of subjects. Food accessibility and availability are also factors that determine the diet patterns of subjects.

Furthermore, attention should be paid on vitamin D intake of athletes since about one third (n=22, 34.4%) of the subjects in this study sample did not meet the requirement of Malaysian RNI. There was more concern on indoor athletes who did not achieve RNI rather than outdoor athletes because outdoor athletes would be exposed longer under the sun which might help in reducing the risk for poor vitamin D status.

The average body fat percentage in both indoor as well as outdoor athletes was in the range of good and acceptable, according to the rating scale of body fat percentage levels in this study, which promoting optimal vitamin D production with ideal body fat percentage level. Only few athletes were found to be overweight and obese and attention should be paid to them. Body fat percentage of athletes should be monitored regularly in order to maintain in healthy range, which could optimize the capability of the skin in producing vitamin D.

In this study sample, types of sports do play an important role in determining the chances to be exposed to the sun. The training patterns, extensive training hours and locations for indoor athletes diminished their opportunities to carry out their activities under the sun. Higher sun exposure in outdoor athletes was mostly due to their training patterns and locations. The study by Halliday *et al*. (2011)[11] also found that the vitamin D status of the athletes who were involved in their study is correlated with the estimated weekly outdoor practice time, but not the leisure time.

Persons with low sun exposure are those spending 20 minutes per day averagely in direct sun with about 18% BSA exposed while those spending an average of 90 minutes per day in direct sun with about 35% BSA exposed are known as having high sun exposure.[13] Indoor athletes in this study could be categorized as slightly low sun exposure whereas the outdoor athletes had relatively high sun exposure. It was found that indoor athletes were more likely to have the habits of sunscreen use too. Therefore, indoor athletes who spent lesser time outside, with lower percent BSA exposed and SEI, would have higher probability of low vitamin D status.

The skin type of subjects, which were determined by their ethnicities and skin pigmentation, is one of the components in determining the quantity of cutaneous synthesized vitamin D. Outdoor athletes were more likely to have darker skin due to their ethnicities (Malay and Indian) as well as greater melanin production as a result of response to greater sun exposure. On the other hand, indoor athletes might tend to have fairer skin for the same reasons as well.

Hall (2009)[19] estimated that persons with low skin reflectance or darker skin would need 6-9 times the amount of time under the sun compared to those with high skin reflectance. In other words, subjects with darker skin or greater number of melanin, the natural sunscreen in the skin, are required a longer duration of sun exposure compared to fairer-skinned subjects in order to obtain the same amount of dermally synthesized vitamin D. It be said that darker-skinned subjects would have higher risk of having low vitamin D status for to this reason.

However, persons with darker skin are less sensitive and less likely to experience sunburn. Thus, persons who have greater skin type (darker skin) could spend longer time under the sun. Besides skin colour, sun sensitivity or photosensitivity of skin is another characteristic described in Fitzpatrick skin type classification.[15] Using the same classification, the study by Chan, Jaceldo-Siegl and Fraser (2010)[20] found that those with greater ability to tan, minimal or insensitive skin, spend more time outside explaining the higher levels of serum 25(OH)D with increasing skin type. Therefore, skin type not only determines the amount of vitamin D production, but also the duration of sun exposure that an individual can sustain. The characteristics of the skin type are complement to each other and in turn enable individuals to achieve optimal endogenous synthesis of vitamin D through sun exposure.

Vitamin D intake is the alternative source of vitamin D besides sun exposure. Hence, intake of vitamin D could be adjusted in order to meet optimal vitamin D status depending on the sun exposure habits of athletes. Hall *et al*. (2010)[14] suggested that persons with high skin reflectance (fairer skin) and high sun exposure are at low risk of vitamin D inadequacy and a supplemental intake of 25 µg (100 IU) to 63.75 µg (2550 IU) per day is needed for those persons depending on the season to maintain optimal vitamin D status. For those who have low skin reflectance (darker skin) and low sun exposure they need to be supplemented with 52.5 µg (2100 IU) to 77.5µg (3100 IU) per day all year-round to achieve and maintain optimal serum 25(OH)D. Thus, indoor athletes should be supplemented with vitamin D or increase their vitamin D consumption from food to maintain their vitamin D status.

In conclusion, these findings showed that indoor athletes were more vulnerable to vitamin D insufficiency since they spent relatively less time under the sun and tended to use sunscreen protective than outdoor athletes. Furthermore, their vitamin D intake from food and supplement were also lower than outdoor athletes. This again increased the risk of vitamin D inadequacy among indoor athletes. The results also showed that almost half of the indoor athletes did not meet the RNI for vitamin D as well. Due to limited resources, the major outcome, vitamin D status, was not measured via serum 25(OH)D in this study. Hence, the current status of subjects and the relationship or impact of the determined factors in this study could not be determined.

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