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Serum Lipid Profile in Premenopausal Garment Factory Workers in Bangladesh: Associations with Serum 25-hydroxyvitamin D Concentrations

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ABSTRACT

There is continuing controversy over the association between serum level of 25-hydroxyvitamin D (S-25 OHD) and cardiovascular risk factors. The aim of the present study was to examine the association between serum lipid profile and S-25 OHD levels in Bangladeshi young female garment factory workers with exclusive indoor lifestyle. A total of 200 subjects (aged 18-36 years) were randomly selected. Fasting S-25 OHD, Total Cholesterol (T-C), Triacylglycerol (TAG), High-density Lipoprotein Cholesterol (HDL-C), Low-density Lipoprotein Cholesterol (LDL-C), Very-low-density Lipoprotein Cholesterol (VLDL-C), LDL-C/HDL-C ratio were measured. About 92% of the subjects were below 30 years of age. A high prevalence (88.5%) of hypovitaminosis D (S-25 OHD <50 mmol L^{-1}) was observed and there was no significant association between S-25 OHD and T-C. The acceptable level of T-C was highly prevalent (92%) in the subjects. The prevalence of high T-C and LDL-C were 1.5 and 2.5%, respectively. The HDL-C level (<1.04 mmol L^{-1}) was predominantly low (about 90%) in the subjects. Data indicated that subjects with S-25 OHD level both <50 and >50 mmol L^{-1} had no influence on T-C, LDL-C, LDL/HDL ratio, VLDL-C and TAG levels. Anthropometric variables such as Body Mass Index (BMI), bicep and tricep skinfolds, Mid-upper Arm Circumference (MUAC), hip and waist circumference had a significant ($p<0.005$) association with T-C and TAG. The results of the study do not support any association of S-25 OHD levels with unfavourable lipid profile. Further intervention studies in different subject groups are warranted to evaluate whether increasing vitamin D intake with supplementation or increased exposure to sunlight will improve the metabolic cardiovascular risk factors profile.

Key words: Cholesterol, triacylglycerol, vitamin D status, female garment workers, Bangladesh

INTRODUCTION

FSO (2003) has indicated that only the two diseases (cardiovascular disease and non-insulin dependent diabetes mellitus) account for up to 50% of all deaths in western countries. The mortality rate caused by these diseases is increasing rapidly in developing countries (Yusuf *et al.*, 2001; Wild *et al.*, 2004). Optimal vitamin D status is associated not only in maintaining the bone health or normal function of many organs and tissues throughout the body but also involve in protecting against many chronic conditions including autoimmune diseases, diabetes, cardiovascular diseases and cancers (Holick, 2006; Zittermann, 2006). Vitamin D status has been shown to be associated inversely with cardiovascular disease and mortality which was also supported in a meta-analysis of 18 randomized controlled trials (Autier and Gandini, 2007; Dobnig *et al*., 2008; Melamed *et al*., 2008; Pilz *et al*., 2009). Several studies indicated the association between low vitamin D status and high blood pressure, blood glucose and body mass index (Need *et al*., 2005; Snijder *et al*., 2005; Scragg *et al*., 2007; Witham *et al*., 2009). On the contrary, a number of studies also reported that there is no consistent association between vitamin D status and cardiovascular risk factors and mortality (Pittas *et al*., 2010; Wang *et al*., 2010; Jassal *et al*., 2010). However, the association between serum 25 hydroxyvitamin D and serum lipids is still ambiguous and controversial.

The export-based garment industries in Bangladesh are dominated by female labour and have employed more than 4 million young women. These young women typically work from dawn to dusk, 7 days week^{-1} in an over-crowded, congested and poorly ventilated sub-standard environment.

The present study was designed to evaluate the association between serum 25-hydroxyvitamin D and serum lipids in a representative sample of Bangladeshi low-income young female garment factory workers with exclusive indoor lifestyle.

SUBJECTS AND METHODS

Subjects: This study was conducted in an export-oriented garment factory with a high quality working environment for their workers and belonging to Standard Groups Bangladesh. The garment factory is situated in Mirpur in the city of Dhaka. A total of 200 subjects aged 18-36 years were randomly selected from the garment factory. The subjects of this study were mainly young women from low-income rural families. They live in low-cost accommodations close to the factory. They work dawn to dusk, seven days a week and use traditional dresses. The eligibility criteria to include the subjects in this study was no history of serious medical conditions, no history of medication known to affect bone or lipid metabolism, no current pregnancies, no lactation within the previous three years and lived in the city for at least two years. The first approach was to contact the Chief Medical Officer of the Standard Group, to explain the purpose of the study and to ask for their co-operation. The subjects were communicated through the Chief Medical Officer and explained to them the objectives of the study in an understandable way and asked for their written consent. In the morning of weekly working days, a small group of about ten subjects were brought in a minibus to the Centre for Nuclear Medicine and Ultrasound, Sir Salimullah Medical College, Mitford, Dhaka, where fasting blood samples, background information and anthropometric measurements were carried out sequentially. The subjects received a small monetary reward for their loss of one day's work.

Laboratory measurements: Fasting blood samples were collected between 8:30 and 10:00 AM. The serum was separated and preserved at -20°C. Finally, the serum sample was transported to Helsinki in a special type of container with dry ice and preserved in the freezing room of the Division of Nutrition, Department of Food and Environmental Sciences, University of Helsinki at -20°C temperature until analysed.

Serum 25-hydroxyvitamin D was used to evaluate vitamin D status. The concentration was determined by the enzyme-immunoassay method with kits from OCTEIA (IDS, Boldon, UK). The laboratory is a partner of the Vitamin D External Quality Assessment Scheme, (DEQAS, www.DEQAS.org.uk). The intra-and inter-assay CVs were 5.4 and 7.0%, respectively. Serum intact parathyroid hormone (S-iPTH) level was measured with a commercial two-site immunoenzymometric assay (OCTEIA, IDS, Boldon, UK), with 10-65 ng L^{-1} as a reference range. Intra-and inter-assay CVs for S-iPTH were 3.5 and 5.6%, respectively. Serum total cholesterol (T-C), high density lipoprotein cholesterol (HDL-C), triacylglycerol (TAG) were measured with an automated KoneLab spectrophotometer (Thermo Clinical Labsystems Ltd., Espoo, Finland) using routine methods. The concentration of serum VLDL-C was calculated by using the equation VLDL-C = TAGx0.45 and the concentration of serum LDL-C by using the equation LDL-C = T-C−HDL-C−VLDL-C (Andersen *et al.*, 2009).

According to the criteria used for Asian young subjects the T-C was categorized as: Acceptable, <4.92 mmol L^{-1}; borderline, 4.92-5.70 mmol L^{-1} and high >5.70 mmol L^{-1} (Okada *et al.*, 2002; Li *et al.*, 2004). LDL-C level was categorized as: Acceptable <2.85 mmol L^{-1}; borderline, 2.85-3.63 mmol L^{-1} and high >3.63 mmol L^{-1}. The cut-off value for TAG was 1.58 mmol L^{-1} and for HDL-C was 1.04 mmol L^{-1}. The criteria for vitamin D deficiency, insufficiency and sufficiency were defined as S-25 OHD levels <50, 50-75 and >75 mmol L^{-1}, respectively (Holick, 2006; Bischoff-Ferrari *et al.*, 2006). The laboratory analysis was carried out at the Department of Food and Environmental Sciences, University of Helsinki, Finland.

Other data: The food composition database used in this study contains no vitamin D, thus the estimation of dietary vitamin D intake was not possible. A questionnaire was used to collect information on height, weight, age at menarche, length of living in the city, daily time spent outdoors, monthly income etc. Height, weight, biceps, triceps skinfolds, MUAC; head, waist and hip circumference were measured. Standing height was measured with a wall-mounted scale to the nearest 0.5 cm. Body weight was measured without shoes and with light clothing on a portable weighing scale to the nearest 0.5 kg. We used the classifications of Body Mass Index (BMI) [weight (kg)/height (m^2)] recommended by the WHO (1995). A Harpenden calliper was used to measure Skinfold Thicknesses (SFT) and a measuring tape was used for the measurements of MUAC, head, waist and hip circumference.

Statistical analyses: The statistical analysis was completed using PASW version 18.0 (SPSS Inc, Chicago, IL, USA). Data are presented as means±SDs. Serum lipid data and other selected variables were tested with ANOVA and analysis of covariance to show the effect of confounding factor. Comparison of groups in analysis of covariance was performed. Correlation between variables were estimated by using Pearson's coefficient of correlation. p values <0.05 were considered significant.

RESULTS

The mean monthly income of the subjects was USD 42.8. We categorised 4-levels of education among subjects which is presented in Table 1. Of note, the studied subjects were mainly young women and 92% of them were below thirty years old. About 12% of the subjects had BMI <18.5 which indicate their vulnerability to malnutrition. We observed 13.5% subjects had BMI value above the upper limit of desirable range (BMI >25).

A high prevalence (88.5%) of hypovitaminosis D (S-25 OHD <50 mmol L^{-1}) was observed in the subjects. Detailed information on S-25 OHD concentrations and a summary of the descriptive,

Table 1: Educational qualification of the subjects

Classification	Level of education	No.	Percentage
Category 1	Illiterate	20	10.0
Category 2	Primary	124	62.0
Category 3	SSC* to HSC**	41	20.5
Category 4	Graduation and above	15	7.5

*Scondary school certificate, **Higher secondary certificate

Table 2: Descriptive and biochemical characteristics of the subjects (n = 200)

Parameters	Mean (SD)	Range
Age (years)	22.6 (3.7)	18-38
HDL-C (mmol L^{-1})	0.76 (0.21)	0.36- 1.68
LDL-C (mmol L^{-1})	2.31 (0.68)	0.96-5.53
LDL-C/HDL-C	3.21 (1.18)	1.04- 7.37
T-C (mmol L^{-1})	3.85 (0.81)	2.10- 7.80
TAG (mmol L^{-1})	1.21 (0.59)	0.37- 4.16

HDL-C: HDL cholesterol, LDL-C: LDL cholesterol, T-C: Total cholesterol, TAG: Triacylglycerides

Table 3: Lipid and lipoprotein classifications in young female garment factory workers in Bangladesh and percentage of subjects at different cut-off levels (Okada *et al*., 2002)

Classification	mmol L^{-1}	No.	Percentage
Total cholesterol			
Acceptable	<4.92	184	92.0
Borderline	4.92-5.70	13	6.5
High	>5.70	3	1.5
LDL cholesterol			
Acceptable	<2.85	159	79.5
Borderline	2.85-3.63	36	18.0
High	>3.63	5	2.5
HDL cholesterol			
Normal	>1.04	21	10.5
Low	<1.04	179	89.5
Triacylglyserol			
Normal	<1.58	157	78.5
High	>1.58	43	21.5

LDL: Low density lipoprotein, HDL: High density lipoprotein

biochemical characteristics of the subjects have been described elsewhere (Islam *et al*., 2010). Table 2 shows the mean, standard deviation and range of HDL-C, LDL-C, T-C and TAG. Lipid and lipoprotein classifications and percentage of subjects in different cut-off levels is presented in Table 3. HDL-C was predominantly low in the subjects. Nearly 90% of the subjects had HDL-C below the normal level (<1.04 mmol L^{-1}). The T-C and LDL-C concentrations were uniformly low in the subjects. No significant inverse association between S-25 OHD and T-C (r -0.12, p = 0.07) was observed. Data showed that subjects with S-25 OHD <50 or >50 mmol L^{-1} had no significant influence on T-C, LDL-C, HDL-C, LDL/HDL ratio, VLDL-C and TAG levels (Table 4). No influence of age on biochemical and anthropometric variables was observed except for S-25 OHD level ($p<0.05$). The results indicate lower level of S-25 OHD with increasing age (Table 4). There was no significant association between S-25 OHD and BMI (r -0.05; p = 0.49) in these subjects.

Table 4: Comparison of the physical and biochemical characteristics of the subjects with age above and below 30 year and serum 25-hydroxyvitamin D levels above and below 50 mmol L^{-1} (BMI was used as covariate for S-25 OHD and serum lipid variables)

	Age (year)			S-25 OHD (mmol L^{-1})		
Parameters	<30	>30	p-value	<50	>50	p-value
Cases	184	16	-	178	22	-
Weight (kg)	48.4±6.7	50.8±7.7	0.52	48.5±6.7	49.2±7.5	0.25
Height (cm)	149.9±5.1	149.3±4.4	0.46	149.9±5.0	149.5.±5.1	0.42
BMI (kg m^{-2})	21.5±2.7	22.7±2.7	0.97	21.6±2.7	22.0±3.0	0.33
Bicep skinfold (mm)	4.6±1.7	4.8±1.4	0.62	4.6±1.6	4.4±1.7	0.60
Tricepskinfold (mm)	11.4±3.5	12.4±3.7	0.50	11.5±3.5	11.4±3.6	0.75
WC (cm)	72.1±6.9	74.5±6.8	0.61	72.2±6.8	72.9±7.6	0.98
HC (cm)	89.3±6.7	91.9±8.1	0.56	89.4±6.9	89.6±6.5	0.29
MUAC (cm)	24.5±2.5.	24.8±3.3	0.70	24.7±2.5	23.3±2.7	0.92
S-25 OHD (mmol L^{-1})	37.3±11.2	30.4±10.2	0.02	34.2±8.3	57.3±8.3	0.00
S-iPTH (ng L^{-1})	22.5±10.9	30.4±14.1	0.18	23.5±11.6	20.2±9.7	0.68
HDL-C (mmol L^{-1}	0.75±0.16	0.84±0.25	0.84	0.76±0.21	0.75±0.17	0.19
LDL-C (mmol L^{-1})	2.29 ±0.68	2.50±0.63	0.62	2.34±0.68	2.08±0.56	0.29
LDL-C/HDL-C	3.22±1.19	3.18±1.16	0.68	3.25±1.19	2.91±1.08	0.56
T-C (mmol L^{-1})	3.82±0.80	4.20±0.80	0.93	3.88±0.81	3.60±0.74	0.23
TAG (mmol L^{-1})	1.19±0.59	1.37±0.60	0.82	1.21±0.61	1.15±0.46	0-56
S-creatinine (μmol L^{-1})	75.9±14.1	82.9±14.5	0.79	76.3±13.3	77.9±20.2	0.82

WC: Waist circumference, HC: Hip circumference, MUAC: Mid upper arm circumference, BMI: Body mass index, HDL-C: HDL cholesterol, LDL-C: LDL cholesterol, T-C: Total cholesterol, TAG: Triacylglycerides

DISCUSSION

The study investigated the association between vitamin D status and lipid profile in young low income female garment factory workers with a high prevalence of suboptimal vitamin D status. In fact, several studies reported divergent results about the relation between S-25 OHD and T-C. A negative association was reported between S-25 OHD and T-C in some studies (Melamed *et al.*, 2008) whereas some studies found positive association between S-25 OHD and T-C (Jorde *et al.*, 2010). In addition, some study did not find any significant association between fasting serum lipids and S-25 OHD (Forouhi *et al.*, 2008). However, in the present study we also observed no significant association between S-25 OHD and serum T-C, LDL-C, HDL-C and TAG in our subjects.

Generally, most of the lipid abnormalities are markers of dietary excess, low physical activity, increasing obesity, increasing age (Jenum *et al.*, 2006). The results showed that more than 90% of the subjects in the present study had accetable level of serum T-C (<4.92 mmol L^{-1}). The possible reason of a high prevalence of normal level of T-C could be their low dietary intake, low income level, high physical activity, young adult subjects with the lower BMI. Therefore, it can be mentioned that the result could have been different had we selected the subjects from high income level and older female with higher BMI.

The present subjects were a homogenous group because they were working in a similar occupational setting, developmentally similar as they came from low-income families. However, the results of the present study showed that subjects with higher S-25 OHD levels (>50 mmol L^{-1}) had no significant difference in T-C, LDL-C, HDL-C, TAG concentrations and LDL-C/HDL-C ratio than those with lower S-25 OHD levels (<50 mmol L^{-1}). The findings do not supports that a high level of S-25 OHD is associated with a desirable lipid profile with low serum T-C, LDL-C, TAG concentrations and LDL-C/HDL-C ratio (Bansal *et al.*, 2007; Fernandez and Webb, 2008;

Jorde *et al*., 2010). In addition, there was no influence of age on serum lipids in the subjects. The narrow age range of the subjects might be one of the reasons for this situation.

Due to increasing trend of life expectancy of women in Bangladesh, the rate of health problems related to manopause is rising dramatically. Reports indicated that early menopause is frequently observed among South Asians than among Western Caucasians (Alekel *et al*., 1999; Shatrugna *et al*., 2005). A statistically significant increase in serum total cholesterol and triglycerides were observed in Indian postmenopausal women compared with premenopausal women (Bhagya *et al*., 2011). Oestrogen is one of the important female sex hormone. The fall in oestrogen levels after menopause can cause physiological changes in women. The potential role of oestrogen in lipid metabolism is well recognized. The postmenopausal influences in serum lipid profiles might be associated with increase the risk of coronary heart disease among elderly Bangladeshi women. In the present study, a significant influence of age on S-25 OHD levels was observed. Therefore, further studies in women of different age groups and socio-economic classes are required to generate more representative results.

There is paucity of similar data from low income countries. To the best of knowledge, no data exist concerning the association of low S-25 OHD and lipid profile in premenopausal low income Bangladeshi women so that any comparison of the results are not possible. However, the findings of the study needs further confirmation. If the results of the present study is confirmed and supported by other studies this could contribute to an explanation in contrast to the relation between low S-25 OHD levels and increased risk of mortality (Melamed *et al*., 2008; Pilz *et al*., 2009).

The relative contributions of serum lipoproteins to overall cardiovascular disease risk have been substantially studied over the last few decades. It is well known that HDL-C have antithrombotic properties and protect against atherosclerosis. A very high prevalence (90%) of low HDL-C in the subjects were observed which may account for a significant increase in cardiovascular disease and could be a major concern for future health of these subjects.

Limitions to the study: The subjects included in the present study may have vitamin D and lipid status different from that of the Bangladeshi female population in general. The population-based study in different age groups, professions and random selection criteria of the subjects could provide better evidence on the association between vitamin D and lipid status. Secondly, the cut-off values of S-25 OHD to identify vitamin D deficiency, insufficiency and sufficiency are controversial and always changing. In addition, due to some technical limitations, we could not measure dietary vitamin D intake and blood pressure in the subjects which could add the weight to the study.

CONCLUSION

The findings of the present study do not support any association between S-25 OHD and lipid profile. Further intervention studies in different subject groups are warranted to evaluate whether increasing vitamin D intake with supplementation or increased exposure to sunlight will affect the metabolic cardiovascular risk factors profile.

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REFERENCES

Alekel, D.L., E. Mortillaro, E.A. Hussain, B. West and N. Ahmed *et al*., 1999. Lifestyle and biologic contributors to proximal femur bone mineral density and hip axis length in two distinct ethnic groups of premenopausal women. Osteoporosis Int., 9: 327-338.

Andersen, R., C. Brot, H. Mejborn, C. Molgaard, L.T. Skovgaard, E. Trolle and L. Ovesen, 2009. Vitamin D supplementation does not affect serum lipids and lipoproteins in Pakistani immigrants. Eur. J. Clin. Nutr., 63: 1150-1153.

Autier, P. and S. Gandini, 2007. Vitamin D supplementation and total mortality: A meta-analysis of randomized controlled trials. Arch. Int. Med., 167: 1730-1737.

Bansal, S., J.E. Buring, N. Rifai, S. Mora, F.M. Sacks and P.M. Ridker, 2007. Fasting compared with nonfasting triglycerides and risk of cardiovascular events in women. JAMA, 298: 309-316.

Bhagya, V., N.R. Hemalatha, H.B. Veeranna and V. Banu, 2011. Serum lipid profile in prepubertal, reproductive and postmenopausal women. Int. J. Biol. Med. Res., 2: 639-642.

Bischoff-Ferrari, H.A., E. Giovannucci, W.C. Willett, T. Dietrich and B. Dawson-Hughes, 2006. Estimation of optimal serum concentrations of 25-hydroxyvitamin D for multiple health outcomes. Am. J. Clin. Nutr., 84: 18-28.

Dobnig, H., S. Pilz, H. Scharnagl, W. Renner and U. Seelhorst *et al*., 2008. Independent association of low serum 25-hydroxyvitamin D and 1,25-dihydroxyvitamin D levels with all-cause and cardiovascular mortality. Arch. Int. Med., 168: 1340-1349.

FSO, 2003. Statistical Year Book for Foreign Countries. Wiesbaden, Germany.

Fernandez, M.L. and D. Webb, 2008. The LDL to HDL cholesterol ratio as a valuable tool to evaluate coronary heart disease risk. J. Am. Coll. Nutr., 27: 1-5.

Forouhi, N.G., J. Luan, A. Cooper, B.J. Boucher and N.J. Wareham, 2008. Baseline serum 25-hydroxy vitamin d is predictive of future glycemic status and insulin resistance: The medical research council ely prospective study 1990-2000. Diabetes, 57: 2619-2625.

Holick, M.F., 2006. High prevalence of vitamin D inadequacy and implications for health. Mayo Clin. Proc., 81: 353-373.

Islam, M.Z., A.A. Shamim, H.T. Viljakainen, M. Akhtaruzzaman and A.H. Jehan *et al*., 2010. Effect of vitamin D, calcium and multiple micronutrient supplementation on vitamin D and bone status in Bangladeshi premenopausal garment factory workers with hypovitaminosis D: A double-blinded, randomized, placebo-controlled 1-year intervention. Br. J. Nutr., 104: 241-247.

Jassal, S.K., M. Chonchol, D. von Muhlen, G. Smits and E. Barrett-Connor, 2010. Vitamin D, parathyroid hormone and cardiovascular mortality in older adults: The rancho bernardo study. Am. J. Med., 123: 1114-1120.

Jenum, A.K., S.A. Anderssen, K.I. Birkeland, I. Holme and S. Graff-Iversen *et al*., 2006. Promoting physical activity in a low-income multiethnic district: Effects of a community intervention study to reduce risk factors for type 2 diabetes and cardiovascular disease: A community intervention reducing inactivity. Diabetes Care, 29: 1605-1612.

Jorde, R., Y. Figenschau, M. Hutchinson, N. Emaus and G. Grimnes, 2010. High serum 25-hydroxyvitamin D concentrations are associated with a favorable serum lipid profile. Eur. J. Clin. Nutr., 64: 1457-1464.

Li, S., X. Liu, T. Okada, F. Iwata, M. Hara and K. Harada, 2004. Serum lipid profile in obese children in China. Pediatrics Int., 46: 425-428.

Melamed, M.L., E.D. Michos, W. Post and B. Astor, 2008. 25-hydroxyvitamin D levels and the risk of mortality in the general population. Arch. Int. Med., 168: 1629-1637.

Need, A.G., P.D. O'Loughlin, M. Horowitz and B.E.C. Nordin, 2005. Relationship between fasting serum glucose, age, body mass index and serum 25 hydroxyvitamin D in postmenopausal women. Clin. Endocrinol., 62: 738-741.

Okada, T., M. Murata, K. Yamauchi and K. Harada, 2002. New criteria of normal serum lipid levels in Japanese children: The nationwide study. Pediatrics Int., 44: 596-601.

Pilz, S., H. Dobnig, G. Nijpels, R.J. Heine and C.D.A. Stehouwer *et al*., 2009. Vitamin D and mortality in older men and women. Clin. Endocrinol., 71: 666-672.

Pittas, A.G., M. Chung, T. Trikalinos, J. Mitri and M. Brendel *et al*., 2010. Systematic review: Vitamin D and cardiometabolic outcomes. Ann. Internal Med., 152: 307-314.

Scragg, R., M. Sowers and C. Bell, 2007. Serum 25-hydroxyvitamin D, ethnicity and blood pressure in the third national health and nutrition examination survey. Am. J. Hypertens, 20: 713-719.

Shatrugna, V., B. Kulkarni, P.A. Kumar, K.U. Rani and N. Balakrishna, 2005. Bone status of Indian women from a low-income group and its relationship to the nutritional status. Osteoporosis Int., 16: 1827-1835.

Snijder, M.B., R.M. van Dam, M. Visser, D.J.H. Deeg and J.M. Dekker *et al*., 2005. Adiposity in relation to vitamin D status and parathyroid hormone levels: A population-based study in older men and women. J. Clin. Endocrinol. Metab., 90: 4119-4123.

WHO, 1995. Physical status: The use and interpretation of anthropometry. Technical Report Series 354, World Health Organization Geneva, Switzerland.

Wang, L., J.E. Manson, Y. Song and H.D. Sesso, 2010. Systematic review: Vitamin D and calcium supplementation in prevention of cardiovascular events. Ann. Internal Med., 152: 315-323.

Wild, S., G. Roglic, A. Green, R. Sicree and H. King, 2004. Global prevalence of diabetes: Estimates for the year 2000 and projections for 2030. Diabetes Care, 27: 1047-1053.

Witham, M.D., M.A. Nadir and A.D. Struthers, 2009. Effect of vitamin D on blood pressure: A systematic review and meta-analysis. J Hypertens, 27: 1948-1954.

Yusuf, S., S. Reddy, S. Ounpuu and S. Anand, 2001. Clinical cardiology: New frontiers global burden of cardiovascular diseases part I: General considerations, the epidemiologic transition, risk factors and impact of urbanization. Circulation, 104: 2746-2753.

Zittermann, A., 2006. Vitamin D and disease prevention with special reference to cardiovascular disease. Prog. Biophys. Mol. Biol., 92: 39-48.