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The effect of sunlight (ultraviolet) exposure and vitamin D intake deficiency towards the increase of systolic blood pressure

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A B S T R A C T

Hypertension is one of the commonest diseases found on worker, especially night shift worker, such as doctors and nurses. This disease possibly happens on under roof worker like in the office or indoors. This fact was derived from the finding of Qureshi *et al.* (2009) stating that 20% nurses in US suffering hypertension. Recently, there are some investigations about the correlation between lack of vitamin D content in the blood and hypertension. These lead the researchers' interest in studying the correlation among sunlight exposure and vitamin D intake deficiencies towards hypertension. This study was an experiment in which the subjects were *Rattus norvegicus*. They were investigated to reveal the impact of sunlight omission, vitamin D reduction and hypertension. The subjects were placed in a dark cage and fed with vitamin D free food. On the following days, the subjects were moved in the bright room and supplied with vitamin D (0.25µg/kg body weight). The absence of sunlight by situating the subjects in the dark area and supplying non vitamin D food affected the rise of systolic blood pressure significantly ($p = 0.01$). The decline of vitamin D content in the blood happened after the gradual omission of vitamin D along seven days ($p = 0.035$). The relocation of the cage to the rich sunlight room together with feeding the subjects 0.25µg/kg body weight of vitamin D influenced the increase of vitamin D content in the blood since the first day of reposition. However, the significant decline of systolic pressure and noteworthy vitamin D increase ($p = 0.001$) happened after four day vitamin D supply. The sunlight (ultraviolet) exposure and vitamin D intake is influencing towards the increase of vitamin D content and decline of systolic blood pressure on *Rattus norvegicus*.

Introduction

Hypertension is a health problem that affects 30% of the adult population in the United States (Ong *et al.*, 2007) and the number of cases tend to increase. Hypertension is

found in many workers, especially night shift workers, such as doctors and nurses. The disease is also found in workers who always were in indoor room/closed building. Qureshi et al. (2009) stated that 20% of nurses in the U.S. suffering from hypertension.

This condition is suspected relating to low levels of vitamin D in the blood of the workers, because they are less exposed to sunlight (ultraviolet). The data show nearly one third of Americans suffering from lack of vitamin D in the blood (Judd *et al.*, 2008). The habit that tend to avoid sun, such as the use of an umbrella, use of sunscreen lotion, use of a long shirt and always indulge in the building might play a role in increasing vitamin D deficiency in the blood. This happens because the body with less sunlight exposure is difficult to have optimal vitamin D biosynthesis in the skin (Murray *et al.*, 2009).

Recently, many studies have reported an association between vitamin D levels in the blood with blood pressure (Hermawan *et al.*, 2012; Giovannucci, 2009; Rostand, 1997; Li *et al.*, 2002). This is possible to occur due to the secretion of rennin in the renin-angiotensin-aldosterone system that seems to be connected with low levels of vitamin D in the blood.

Li et al. (2002) reported that animals possessed with vitamin D could decrease the production of rennin by directly reducing rennin production in the kidney, however, its mechanism has not been explained certainly. They suspect that vitamin D directly suppresses gene that encoding rennin, rennin that is not produced in sufficient quantities. If renin is produced less, then there would not be enough material to activate the renin-angiotensin- aldosterone, the final impact is increase of blood pressure.

This condition is interesting and still raises many questions. If the correct levels of vitamin D are associated with increased blood pressure, then it should be in tropical regions such as Indonesia will lower the incidence of hypertension, but in reality the incidence of hypertension was reported quite high. In 2007, it was reported prevalence of 17–22% and increased to 32.2% in 2009 (Rahajeng *et al.*, 2010). This has attracted researchers to investigate further the effects of lack of sunlight to decreased levels of vitamin D and increased blood pressure.

Materials and Methods

This study is an experimental research using experimental animals (*Rattus norvegicus*) to examine the effect of the removal of sun exposure, decrease of vitamin D blood level and the incidence of hypertension. The subjects were situated in a dark cage and fed with free-vitamin D in a few days and then moved into a lighted cage, then fed by vitamin D. The subjects in this study were white male rats (*Rattus norvegicus*) aged 8 weeks which were obtained from laboratorium penelitian & pengujian terpadu Gadjah Mada University (UGM LPPT), Yogyakarta. Maintenance and treatment as well as systolic blood pressure measurements performed in the animal laboratory PAU UGM. They were divided into 5 groups and treated according to the research scheme (Fig. 1).

Result and Discussion

Once the subject was placed in a dark cage and fed without vitamin D, the average levels of 1,25 (OH)2D3 blood seen in Figure 2.

In Figure 2, it showed that from day to day there was a decrease in the levels of 1,25 (OH)2D3 blood. On the first day of the

removal of vitamin D intake of 1,25(OH)2D3 from 26.2 μg becoming 12.8 μg on the 13th day of the removal of vitamin D intake. On the other hand, it seemed to have an increase in systolic blood pressure of experimental animals. On the first day of the removal of vitamin D intake, systolic blood pressure was 88 mmHg and increased to 130 mmHg after the 13th day of removal. Decreased levels of vitamin D in the blood and an increase in SBP occurs significantly since the fourth day in a dark cage, but it would look very significant after seven days in a dark cage (p: 0.001).

If the data of decreased 1,25(OH)2D3 was correlated with the increase of blood pressure, it will be presented in Figure 3.

Figure 3 presents that the lower level of 1,25(OH)2D3 with the higher systolic blood pressure of experimental animals. By using the correlation test, it is showed that there was significant correlation between the levels of 1,25(OH)2D3 with an increase in blood pressure with p: 0.007. The significant level is also very close correlation with the value of r: 0.97.

On the other hand, after the animals were placed back in light cage and given oral vitamin D intake of 0.25 μg/kg of body weight (BW)/day for several days, it indicates the increase of 1,25(OH)2D3 blood and a decrease in SBP level. The average increase of 1,25(OH)2D3 blood and decrease of SBP shown in Figure 4.

From Figure 4, it shows that there was a regain on 1,25(OH)2D3 blood level after the animals were moved back into the lighted cage and fed standard and given additional vitamin D intake of 0.25 mg/kg BW/day. On the first day of administration of 1,25(OH)2D3 in blood, it reached 12.9 μg. It raised into 25.4 μg after five days of administration of vitamin D. Instead systolic blood pressure of experimental animals decreased. It is shown that the systolic blood pressure declined after the animals were placed back in the bright cage and fed with vitamin D of 0.25 mg/kg bw/day. Systolic blood pressure on the first day was still high at 123 mmHg, decreased to 91 mmHg after five days of vitamin D administration. The increase of vitamin D gained followed by the decrease of TDS already apparent from the first day of bright cage, but it would seem very meaningful after four days at bright home (p: 0.001).

If the data of the increase of blood 1,25(OH)2D3 was correlated with the reduction in systolic blood pressure then it will look like in Figure 5.

In Figure 5, it indicates that the higher the levels of blood 1,25(OH)2D3 the lower the systolic blood pressure. By using the correlation test shown, the correlation between elevated levels of blood 1,25(OH)2D3 and blood pressure reduction correlates tightly with r values of 0.95 and significant relation with p: 0.014.

From Figure 2 and 3, it is clear there is a strong correlation between decrease of blood 1,25(OH)2D3 and systolic blood pressure increase in experimental animals during the dark domesticating times with r value of 0.97. The lower the levels of blood 1.25 (OH)2D3 the higher the increase in systolic blood pressure in experimental animals is. The result is consistent with (Rostand, 1997) research in 1997, which states that there is a positive correlation between residence distances to the equator with blood pressure. This condition is hypothesized to be the cause of low levels of blood 1,25(OH)2D3 on those living far from the equator. Low level of blood 1,25(OH)2D3 occurs because the body lacks sunlight exposure,

consequently the body is not able to do biosynthesis to turn pro vitamin D into vitamin D (Hall *et al.,* 2006).

Vitamin D is needed to prevent the occurrence of rennin gene transcription, so that rennin is not formed. If rennin is produced, it will immediately activate the rennin-angiotensin-aldosterone system that results an increase in blood pressure at the end. The detailed mechanism was shown in Figure 6 (Li, 2007; Yuan *et al.,* 2007).

In this study, removal of the intake of vitamin D seen followed by placing experimental animals in dark cages and feeding free vitamin D is able to reduce levels of blood vitamin D and increase systolic blood pressure significantly. If the results of the research in the dark cage is analogized to normal human behavior which moving away from sunlight exposure or a group of workers who worked in night shifts or indoors, it would seem that their potential to experience a lack of vitamin D in their blood. Moreover, it has already been proven that low levels of vitamin D in the blood will cause an increase in systolic blood pressure.

From Figure 4 and 5, there is a strong correlation (r: 0.95) between elevated levels of blood 1,25(OH)2D3 with a drop in blood pressure during the study subjects in the light cage. The higher the rising of blood 1,25(OH)2D3 the lower the systolic blood pressure dropped. The results are consistent with research conducted by (Judd *et al.,* 2008; Forman *et al.,* 2007) it implies vitamin D tend to decline a person's risk of cardiovascular disease including hypertension. Vitamin D can suppress rennin gene (Li, 2007; Yuan *et al.,* 2007), so it does not experience increased rennin production.

In this study shows that the oral giving of vitamin D back and put the animal back in the lighted cage can increase vitamin D levels in the blood, so the SBP back down. This condition strengthens the research that states vitamin D is a negative regulator of the rennin production (Li *et al.,* 2002) and intake of vitamin D can be used to lower the blood pressure of experimental animals (Hermawan *et al.,* 2012).

If the result of research in the bright cage was analogized with human life, they require sunlight exposure (ultraviolet) and adequate vitamin D intake is to maintain vitamin D levels in the blood within normal limits. Normal levels of vitamin D will keep the SBP does not increase, therefore, hypertension could be avoided.

Conclusion

Exposure of sunlight (ultraviolet) and oral intake of vitamin D is important to maintain blood vitamin D levels in the normal range in order to prevent the increase of systolic blood pressure.

Ethical considerations

This study was approved by the ethics committee by issuing an ethics committee letter of approval Ref: KE/FK/282/EC on May 7, 2012. In addition, researchers also have applied the principles of Replacement, Reduction and Refinement in the use of experimental animals.

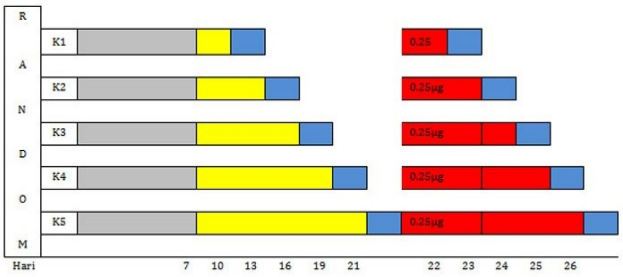
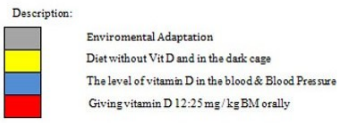


Figure 1. Research Scheme



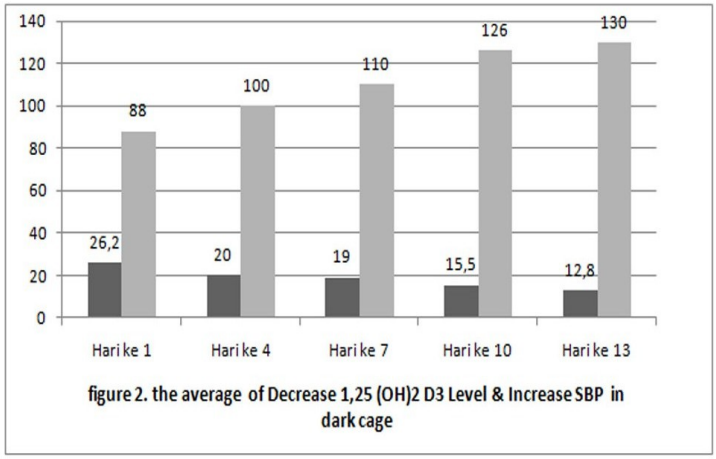


figure 2. the average of Decrease 1,25 (OH)2 D3 Level & Increase SBP in dark cage

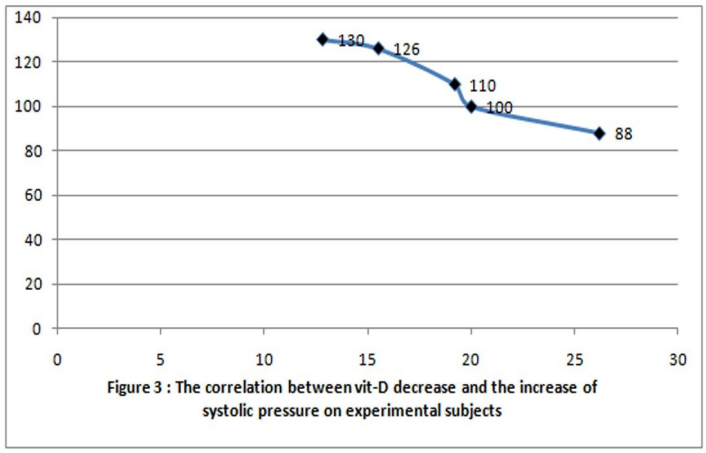


Figure 3 : The correlation between vit-D decrease and the increase of systolic pressure on experimental subjects

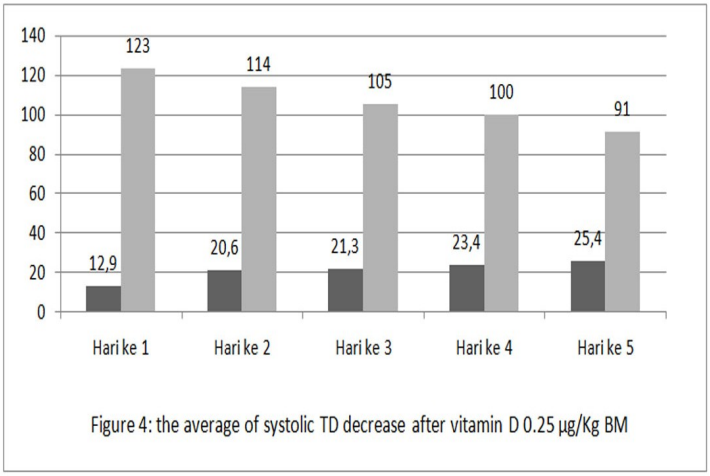


Figure 4: the average of systolic TD decrease after vitamin D 0.25 µg/Kg BM

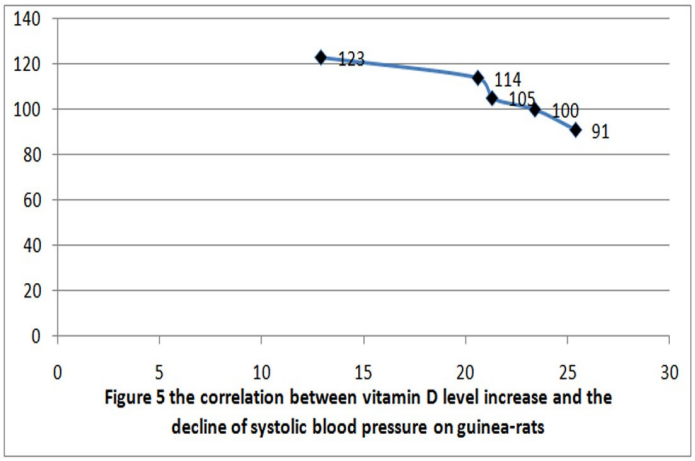


Figure 5 the correlation between vitamin D level increase and the decline of systolic blood pressure on guinea-rats

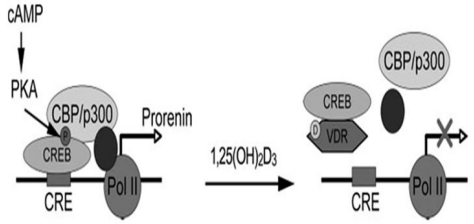


Figure 6. Mechanism of vitamin D as a negative regulator of the renin gene (Yuan et al, 2007)

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