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Do Body Fat and Exercise Modulate Vitamin D Status?

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Obesity has been associated with lower levels of serum 25-hydroxyvitamin D, abbreviated 25(OH)D, in several studies, including the third National Health and Nutrition Examination Survey (NHANES III).[1-19] Body fat has been shown to be a storage site for vitamin D in humans,[20] but the exact mechanism by which higher body fat results in lower serum 25(OH)D is not known for certain. Hypotheses include sequestration in fat,[16] increased clearance by a larger body-fat pool,[3,10] negative feedback from higher circulating $1,25(OH)_2D$ levels in obesity,[2] and decreased sun exposure due to limited mobility or avoidance of outdoor activity.[4] Wortsman et al.[16] found that the increase in serum vitamin D_3 levels after UV exposure was 57% less in obese than nonobese subjects despite similar skin content of the vitamin D_3 precursor, which supports the possibility of sequestration by fat. Other findings consistent with a possible role for sequestration include data in humans showing lower rates of lipolysis in the obese[21] and data in rats showing an increasing accumulation of potentially less-available vitamin D esters in fat over time.[22] There is mixed support for a role of negative feedback from $1,25(OH)_2D$ in explaining lower levels of 25(OH)D in obesity, since higher levels of $1,25(OH)_2$ D in obese subjects have been seen in some, but not all, studies.[2,3,6,18,23] Finally, data showing lower levels of physical activity in obese individuals are available,[24,25] but they do not distinguish between indoor and outdoor activity.

Data from NHANES III suggest that the body fat-vitamin D relationship may be complex. For example, the relationship appears to vary by race, being weaker in African Americans than in Caucasians.[1] Some, but not all, studies based on smaller samples of healthy volunteers have found similar results.[16,23,26] Differences in dermal production of vitamin D or in body fat distribution could potentially contribute to a different relationship between body fat and vitamin D by race. Synthesis of vitamin D in the skin is reduced in blacks due to greater amounts of melanin, which absorbs the UV wavelengths needed to convert 7-dehydroxycholesterol to vitamin D_3 in the skin.[27] If less vitamin D is formed, there may be less available to be sequestered in subcutaneous fat. Differences in the distribution of subcutaneous fat also exist, with blacks having less subcutaneous fat in the extremities and more in the trunk than whites.[28] This could affect the body fat-vitamin D relationship by reducing the amount of fat present to sequester vitamin D in body areas that may be more important for dermal production of vitamin D, given the possibility that the extremities are less likely to be covered with clothing than the body trunk.

Physical activity is also related to serum 25(OH)D, with higher self-reported activity linked with higher levels of 25(OH)D in NHANES III, as well as in other studies.[11,13,29,31] Whether this reflects a direct relationship between activity and vitamin D metabolism or is a result of confounding due to the relationship between physical activity and body fat or sun exposure is not certain. There is conflicting evidence regarding a direct impact of physical activity on the metabolism of 25(OH)D.[29-33] Results of these studies are difficult to interpret due to small sample sizes, lack of control groups, or failure to control for sun exposure. Confounding by body fat appears unlikely to fully explain the relationship between physical activity and serum 25(OH)D; although physical activity was associated with lower body fat in NHANES III, adjusting for body fat did not noticeably attenuate the relationship between physical activity and 25(OH)D. There are some data to support a role for confounding from sun exposure. For example, Scragg et al.[31] reported significantly higher levels of 25(OH)D in those who exercised outdoors than in those who exercised indoors, and Rock et al.[12] found no significant relationship between physical activity and serum 25(OH)D after controlling for hours of sun exposure.

In NHANES III, the relationship between physical activity and serum 25(OH)D differs by race in a manner similar to that seen for body fat, with a weaker relation-

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ship appearing in African Americans than in Caucasians. This difference in relationship by race remained after adjusting for body fat as well, suggesting that it is not accounted for by confounding from this variable. Differences in dermal production of vitamin D from sun exposure during activity could play a role in the different relationship by race, since African Americans may require a longer exposure time than Caucasians to produce a similar amount of vitamin D.[27]

In conclusion, vitamin D status is related to body fat and to physical activity. Data from NHANES III suggest that these relationships may be complex, as both appear to vary by race. More data are needed to clarify the basis for this variation. Understanding these complex relationships may ultimately contribute to a better understanding of this important vitamin.

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