1 Introduction

Vitamin D is a unique nutrient with its ability to be synthesized in the human body upon sun exposure. However, during winter months at northern latitudes the cutaneous vitamin D synthesis is absent. Since few foods are naturally rich in vitamin D, the dietary intake is low in many groups; especially in children were intakes at ~2-3 μg/day are common in European populations\(^1\). These circumstances increase the risk of low vitamin D status. Recently, it was estimated that 18% of European children and adults are vitamin D deficient, with a serum 25-hydroxyvitamin D (25(OH)D) concentration <30 nmol/L, during winter months from October to March\(^2\).

Vitamin D is traditionally linked to skeletal health, and deficiency increases the risk of rickets in children\(^3\). A number of factors of both biological and behavioural character, may associate with serum 25(OH)D in children, such as age, body composition, sun behaviour and dietary intake\(^4\). Therefore, it is a complex task to identify children most at risk of low winter serum 25(OH)D. However, an increased knowledge on potential factors associated with low status can help find those at risk as well as identify strategies to reduce vitamin D inadequacy during winter at northern latitudes.

In spite of much attention and research, there is not complete consensus on the optimal level of vitamin D in the blood or the necessary intakes to achieve this. In 2012, the Nordic Nutrition Recommendations increased their recommended vitamin D intake for Scandinavian child and adult populations from 7.5 to 10 μg/day. They based this on an optimal serum 25(OH)D concentration of >50 nmol/L indicating a sufficient status in relation to bone health\(^5\). However, dietary vitamin D recommendations vary from 10-20 μg/day between countries, and suggested optimal serum 25(OH)D concentrations in blood vary from >25 to >75 nmol/L\(^6-9\). Furthermore, much of the data underlying the current recommendations comes from adults and adolescents, and the results are extrapolated to younger age groups without knowledge on potential age differences.

Besides the classic effect of vitamin D on bone, vitamin D has also been linked to many non-skeletal conditions and health outcomes in children\(^4,10\). One of the areas receiving attention,
is a suggested positive effect of vitamin D on muscle strength and lean mass\textsuperscript{(11,12)} but most of the evidence comes from observational studies or randomized controlled trials in adults and elderly\textsuperscript{(13)}. It is currently unknown if avoidance of the winter decrease in serum 25(OH)D is important for muscle strength and lean mass in healthy children. Moreover, as vitamin D deficiency is linked to slower growth in infants\textsuperscript{(3)}, the question is whether maintenance of sufficient serum 25(OH)D during winter is important for growth and circulating growth factors in healthy children. Randomized trials performed during winter at northern latitudes are needed to investigate these unsolved questions.

This PhD thesis and its three included papers address some of these knowledge gaps within vitamin D research in young children.