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# Effect of micronutrients on tailchasing in dogs

Licenciate thesis

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Tiivistelmä - Referat – Abstract

**OCD (obsessive-compulsive disorder) eli pakko-oireinen häiriö on ihmisen psykiatrinen häiriö, joka ilmenee potilaan pakonomaisina ajatusmalleina ja/tai tapana tehdä rituaalinomaisia tehtäviä. Vastaavanlaista käytöstä on raportoitu myös eläimillä. Tällaista stereotyyppistä käytöstä on esimerkiksi koiran hännänjahtaus, nuoleminen, liiallinen juominen ja näkymättömien "kärpästen" jahtaaminen. Hännänjahtausta esiintyy enemmän tietyillä roduilla, (bullterrierit, staffordshirenbullterrierit, saksanpaimenkoira), joten geneettinen predispositio on todennäköistä.**

**Tutkimusten mukaan ihmisten pakko-oireista häiriötä on hoidettu menestyksellisesti lisäravinteilla. Tiiran ym. vuonna 2012 julkaiseman tutkimuksen mukaan tästä olisi viitteitä myös koiran hännänjahtauksessa. Tämän tutkimuksen tavoitteena oli selvittää tarkemmin ravintoaineiden vaikutusta hännänjahtaukseen koirilla. Hypoteesi on, että häntäänsä jahtaavat koirat saavat vähemmän lisäravinteita.**

**Tutkimusaineisto saatiin professori Hannes Lohen tutkimusryhmältä, jossa tutkitaan hännänjahtaukseen ja muihin pakko-oireisiin vaikuttavia ympäristötekijöitä sekä geneettistä taustaa. Tutkimusaineisto oli kerätty kyselylomakkeella koirien omistajilta samalla tavalla kuin edellinen aineisto, jossa havainto vitamiinien mahdollisesta yhteydestä stereotyyppiseen käyttäytymiseen tehtiin. Minun tutkimukseeni sisällytettiin ne koirat, jotka saivat lisäravinteita. Aineisto koostui bullterriereistä (6), saksanpaimenkoirista (17) staffordshirenbullterriereistä (101) ja amerikanstaffordshirenbullterriereistä (32). Yhteensä koiria oli 156 kpl. Lohen tutkimusryhmän kyselykaavakkeessa kysyttiin mm. koiran hännänjahtauksesta ja lisäravinteiden saannista.**

**Pääkysymykseni oli selvittää, eroaako annettujen lisäravinteiden määrä stereotyyppisesti käyttäytyvien koirien ja kontrollikoirien välillä. Analysoin lisäravinne-luokkien mahdolliset erot jokaisen stereotypiakategorian (hännänjahtaus, nuoleminen, "fly snapping", ja liiallinen juominen) suhteen erikseen, ja lisäksi stereotypia-yhteismuuttujan suhteen Chi-square -testillä. Mikäli stereotyyppisesti käyttäytyvien ja kontrollikoirien välillä jokin lisäaineryhmä erosi merkitsevästi, analysoitiin lisäravinneryhmä vielä tarkemmin Fisherin eksaktilla testillä. Tällä saatiin selville, minkä stereotypian kanssa mikroravinne assosioi.**

**Ainoa lisäravinneryhmä, jolla oli merkitsevä assosiaatio hännänjahtauksen kanssa, oli nivelapuaineet (p = 0,0240). Vitamiineilla (p = 0,078), rasvahapoilla (p = 0,080) ja öljyillä (p = 0,078) näytti olevan ei-merkitsevä assosiaatio nuolemiseen. Millään lisäravinneryhmällä ei näyttänyt olevan tilastollista merkitsevyyttä kärpästen jahtaamisen tai juomisen kanssa. Koirat, joilla ylipäätään oli stereotypioita, saivat enemmän rasvahappoja (p = 0,037) ja öljyjä (p = 0,045) ja vähemmän nivelapuaineita (p = 0,046). Nämä tulokset ovat tilastollisesti merkitsevä.**

**Tässä tutkimuksessa ei löydetty assosiaatiota vitamiinien / mineraalien ja hännänjahtauksen välillä. Tulokset eroavat Tiiran tutkimuksesta. Kuitenkin Tiiran aineisto koostui pääasiassa bullterriereistä, kun taas minun aineistossani suurin osa koirista oli staffeja. Hännänjahtaaja-ryhmä oli kontrolliryhmää nuorempi, mikä voi selittää sitä, että ne saivat vähemmän nivelapuaineita. Koirat, jotka nuolevat, saattavat kärsiä sen seurauksena iho-ongelmista, jolloin omistajat antavat niille öljyjä. Tässä tutkimuksessa ei tiedetä tarkkaa mikroravinnemäärää, mikä saattaa vääristää tuloksia.**

Avainsanat - Nyckelord – Keywords: **hännänjahtaus, stereotyyppinen käytös OCD, pakko-oire, mikroravinne, lisäravinne, vitamiini, mineraali, öljy**

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# 1 INTRODUCTION

Obsessive-compulsive disorder in humans is characterized by intrusive thoughts, rituals or repetitive behaviour, such as cleaning or checking. These obsessions and compulsions interfere significantly with everyday life and are highly distressing (Grisham et al. 2008). Repetitive or sustained abnormal behaviours performed out of context have been described in animals aswell and is referred to as stereotypic behaviour. It is thought to be an exaggerated form of natural behaviour such as feeding or locomotion (Luescher 2003, Tiira et al., 2012).

Tail chasing is a classic, compulsive behavior observed in dogs. It is a repetitive behavior that often occurs in bouts (Tiira et al., 2012). Tail chasing is most commonly observed in Bull Terriers and German Shepherds, but it does occur in a variety of breeds (Moon-Fanelli et al., 2011). As TC is more common in certain breeds, it is suggested to have a genetic predisposition (Tiira et al., 2012), as does human OCD (Cornish et al., 2008).

Studies have shown that dietary nutrients play an important role in the cognitive development of children. Nutrition is said to affect the structure and functioning of the brain due to the high percentage of human metabolic activity accounted by this organ. In humans it is therefore reasonable to assume that during times of rapid growth there are also great demands of nutrients essential for brain development. If nutrition is inadequate, proper brain development is compromised (Benton, 2008).

Deficiencies of various B vitamins have been proven to cause brain dysfunction (Kaplan et al., 2007) and autism has been treated successfully with a combination of pyridoxine and magnesium (Cornish et al., 2008). Vitamins E and C are both important antioxidants in the body and brain (Frazier et al., 2009). Calcium imbalance caused by hyperparathyroidism may result in anxiety, depression and cognitive function (Frazier et al., 2009). Iron deficiency has been shown to effect the dopaminergic system (Weiser et al., 1994) aswell as brain development (Youdim, 2001). Patients with major depression were shown to have lower serum zinc levels in comparison to controls with normal mental health (Maes et al., 1997).

Traditionally, OCD has been treated with cognitive-behavioural therapy and clomipramine and fluoxetine, a serotonergic medication (Altemus et al., 1992; Yalcin 2010). The same drugs are efficient for canine OCD also (Overall et al., 2002). However, as mentioned above, dietary nutrients play an important role in mental health and several mental disorders have been succesfully treated with vitamins and minerals. Previously, the dominant opinion was that mental disorders could be treated with a single vitamin or mineral. Afterwards it has been discussed that dietary interventions of single ingredients may actually upset natural balances and create deficiences in other nutrients (Mertz, 1994). Furthermore, even though many nutrients are important in neurological function, at present there is no compelling evidence that any given single nutrient shows more therapeutic potential than all others (Kaplan et al., 2007). It has also been speculated that as the mammalian nervous system and homeostatic mechanisms are very complex, it would be reasonable that a very broad approach to nutritional supplementation might be appropriate (Kaplan et al., 2001).

A chelated vitamin-mineral supplement, EMPowerplus (EMP+) has successfully been used in several cases of mental disorders to decrease symptoms, even to the extent where pharmacological medication is no longer needed (Kaplan et al., 2001; Popper 2001; Simmons 2003; Kaplan et al., 2004; Rucklidge 2009; Frazier et al., 2009; Rucklidge et al., 2010).

One study has been conducted on the effect of food and nutrients on tail chasing in dogs (Tiira et al. 2012). Interestingly, the dogs who received dietary nutrients had less TC compared to those who did not receive any. After more specific analysis, they found vitamin B6 to be the crucial micronutrient: dogs who received vitamin B6 chased their tail significantly less compared to those who did not receive vitamin B6.

The aim of this study is to do a replicate study on the potential association between the micronutrients and stereotypic behavior in dogs. The study material in my research was collected using the same online stereotypic questionnaire as in the previous study (Tiira et al. 2012) but using a different population of dogs. The main aim of my study is to characterize the dietary nutrients received by dogs with stereotypic behavior and compare that to those received by dogs with no stereotypic behavior.

# 2 LITERATURE REVIEW

## *2.1 Tail chasing and other compulsive disorders in dogs*

Repetitive or sustained abnormal behaviors performed out of context have been described in various species of farm animals, zoo animals and companion animals (Luescher, 2003). This behavior in animals is referred to as stereotypic or obsessive-compulsive behavior (OCD), and is suggested to be exaggerated forms of natural behavior, such as feeding, locomotion or predation (Tiira et al., 2012). Compulsive behaviors in dogs can be categorized as locomotory, oral, aggressive, vocalization and hallucinatory behaviors. Locomotory behaviors include circling, tail chasing (TC), pacing, chasing light reflections and freezing. Leg or foot chewing, flank or blanket sucking, polydipsia and fly snapping are considered to be oral behaviors. Compulsive behaviors related to aggression include self-directed aggression, attacking the food bowl or other objects and unpredictable aggression to people. Vocalization may be compulsive rhythmic barking or whining, and hallucinatory behaviors manifest as staring at shadows and waking up suddenly without any discernible trigger (Luescher, 2003). Interestingly, compulsive behavior has only been observed in captive or domesticated animals (Tiira et al., 2012).

Tail chasing is a classic, compulsive behavior observed in dogs. It is a repetitive behavior that often occurs in bouts (Tiira et al., 2012). It is expressed as slow to rapid circling with the dog's attention directed toward the tail or rapid spinning in tight circles with no apparent focus on the tail. Slow, focused chasing often precedes the rapid, unfocused bouts (Luescher, 2003). Tail chasing is most commonly observed in Bull Terriers and German Shepherds, but it does occur in a variety of breeds (Moon-Fanelli et al., 2011). As TC is more common in certain breeds, it is suggested to have a genetic predisposition (Tiira et al., 2012).

### 2.1.1 Characteristics of tail chasing

#### *2.1.1.1 Sex and neuter status*

Moon-Fanelli et al. (2011) found male dogs to be more susceptible to TC than females. In their study there was an 8 % increase in TC in males compared to females. Also Yalcin (2010) found that male dogs were more often affected than females.

Overall et al. (2002) found no significant association between sex or neuter status and TC in their study population (n = 126), but compared with the sex and neuter data for the entire veterinary teaching hospital canine population during the study period (1989-2000) they found male dogs to be significantly over-represented in the study population. Furthermore, they found neutered males to be over-represented compared to intact males.

In contrast to the above, Tiira et al. (2012) found no difference between males and females in the prevalence of TC, neither was there any difference when only severe cases of TC were included. Males and females didn't differ in either frequency or severity of TC. However, they did find that neutered females had less severe TC-status compared to intact ones, suggesting that neutering in females may have a controlling effect on TC-behavior. They found no association between the neutering age and TC. They were unable to identify whether there was the same kind of difference in males also, as their neutered male population in the study was too small.

#### *2.1.1.2 Age of onset*

All researchers have been fairly unanimous about the age of onset of TC. Moon-Fanelli et al. (2011) found the median age of onset to be 6 months, ranging from 2 months to 6 years. Yalcin (2010) suggested the typical onset at 3 to 12 months of age, as Tiira et al. (2012) suggested it to vary from 3 to 6 months in Bull Terriers and German Shepherds and 6 to 24 months in Miniature Bull Terriers and Staffordshire Bull Terriers. Overall et al. (2002) found the median age of onset of any OCD in dogs to be 12 months. All researches suggest that dogs develop signs of TC at a fairly young age. The median age of onset being 12 months indicates that half of the affected dogs develop TC before 1 year of age.

#### *2.1.1.3 Degree of expression and owner's ability to interrupt*

In the Moon-Fanelli et al. (2011) study 74 % of TC-dogs chased their tail daily and 26 % less than daily. Out of the 74 % daily chasers 70 % did so 2-30 minutes or more than 30 minutes a day, whereas out of the ones who chased their tail less than daily only 10 % did so 2-30 minutes or more than 30 minutes. In the study by Tiira et al. (2012), only 23 % of the study population had severe tail chasing ($TC_{index} \geq 4$).

In the study of Moon-Fanelli et al. (2011) 88 % of the owners were able to interrupt the dog's tail chasing behavior, but nearly half of these dogs would immediately or within minutes resume tail chasing. One-third of the dogs would not resume or did so at a later time and the rest resumed or didn't resume depending on the situation (if the dog was bored or stressed, it was more likely to resume). 10 % of the owners couldn't interrupt the dog and 2 % hadn't even tried to.

In Tiira et al.'s (2012) study 89 % of the owners had tried to stop their dog's TC-behavior, and 61 % of these were able to do so whereas 34 % had difficulties. Nearly half of the dogs responded normally to their owners' calls during the bouts and the other half showed lower responsiveness. Tiira found that the more the dog chased its tail, the more difficult it was to stop the behavior and the less it reacted.

Luescher (2003) suggests that some patients can easily be distracted with an innocuous noise, but some more severe cases can only be interrupted by physically interfering with the behavior. With the most severe cases even that does not work. He also considers that these behaviors might represent a different behavioral pathologic characteristic or that they might simply differ in severity.

#### *2.1.1.4 Triggers*

Literature is again fairly unanimous about the triggers of TC-behavior. Consensus is that the two most common triggers are situations that increase the dog's frustration or level of arousal (i.e. owner's departure and return or visitors) and boredom or lack of mental or physical stimulation (Luescher, 2003; Moon-Fanelli et al., 2011; Tiira et al., 2012 ). Tiira et al. (2012) found that "bored" or "stressed" dogs chased their tail significantly more than those with another trigger-option. Less frequent triggers included sensitivity to sound, physical conditions such as estrus, a dog's excitement or happiness, or food. Only about one-tenth of the owners could not define particular circumstances preceding TC (Moon-Fanelli et al., 2011, Tiira et al., 2012).

It has also been suggested that some cases of TC might be a purely conditioned behavior, as most owners pay attention to the dog when they perform compulsive behavior (Luescher, 2003). On the other hand, there have also been suggestions that dogs may have learnt that their behavior is prohibited and they might control their behavior to the extent that the behavior is presented only minimally or not at all in the presence of others (Overall et al., 2002). This indicates a strong cognitive component for canine compulsive behaviors, where an animal restricted to perform compulsions may move out the owner's sight and continue the compulsive behavior somewhere else (Tiira et al., 2012).

#### *2.1.1.5 Interference with dog's quality of life and owner's relationship with dog*

It has been shown that TC has an effect on the dog's quality of life (Moon-Fanelli et al., 2011, Tiira et al., 2012). In Moon-Fanelli et al. (2011) study 39 % of owners reported no interference of TC with the dog's quality of life, whereas Tiira et al. (2012) found that 72 % of owners had not noticed a negative effect. The difference might result from the fact that Moon-Fanelli's study population was collected from clinical samples and therefore include more severe cases of TC compared to Tiira's population, which was collected from breed clubs and dogs that had given a blood sample to the dog DNA bank. Nevertheless, both studies show that severe TC definitely has a negative effect on the dog's quality of life.

#### *2.1.1.6 Tail-chaser's personality and association of TC with phobias and fear responses*

It has been suggested that trance-like behavior and episodic aggression associate with TC. Also owner-directed aggression and phobias such as noise sensitivity are found to be mildly associated with TC. It was speculated that the cause of owner-directed aggression could be the dog's increased anxiety and frustration while performing TC and the owner's attempts to stop the behavior (Moon-Fanelli et al., 2011). Tiira et al. (2012) had controversial results. They found TC-dogs to be generally shyer and less aggressive toward humans than non-chasers, this being particularly present in males. Tiira also found that TC-dogs had more noise phobia and other stereotypes, such as trance-like behaviour, in consensus with earlier studies. It should be pointed out that in their study, Moon-Fanelli et al. used only Bull Terriers, whereas Tiira et al. also included German Shepherds and Staffordshire Bull Terriers.

Interestingly, Tiira suggested that early life experiences may predispose to various types of anxiety, as they found that TC-dogs were separated earlier from their mothers and experienced lower quality of care from their mothers. In their study, TC-dogs were separated on average at 7 weeks of age whereas in the control group the average age of separation was 8 weeks.

#### *2.1.1.7 The effect of food and nutrients on TC*

There has been only one study on the effect of food and nutrients on TC in dogs (Tiira et al., 2012). In this study, they found no association between TC and food types (industrial, home made specially for the dog and raw food diet, often called Bone and raw food [BARF]), but they did observe a statistically significant association between TC and dietary nutrients. The dogs who received dietary nutrients had less TC compared to those who did not receive any. After more specific analysis, they found vitamin B6 to be the crucial micronutrient: dogs who received vitamin B6 chased their tail significantly less compared to those who did not receive vitamin B6.

#### *2.1.1.8 Other environmental factors*

It has been suggested that any disease that increases the dog's stress level or irritability, such as dermatologic disease causing licking or endocrine imbalance, may contribute to OCD (Luescher, 2003). Only a few dogs have been shown to develop OCD after trauma or some social-situational related stress (Overall et al., 2002). The number of adults in the household hasn't been shown to have an effect on TC (Overall et al., 2002; Tiira et al., 2012), neither has the amount of exercise, time spent alone, age of arrival to household or the number of diagnosed diseases (Tiira et al., 2012).

#### *2.1.1.9 Treatment*

There is evidence indicating that TC might be caused by an aberrant serotonin metabolism and it has been treated successfully with drugs affecting serotonergic metabolism. Dogs with TC have responded well to clomipramine, fluoxetine and somewhat well to amitriptyline (Overall et al., 2002). Of these three drugs, clomipramine and fluoxetine has been found to be the most effective (Luescher, 2003; Overall et al., 2002; Yalcin, 2010).

The owner's behavior toward a dog performing an OCD might also have an effect. Inappropriate use of punishment, inconsistent routines and frustration increase the dog's stress level, which might enhance the unwanted OCD behavior. Therefore it is suggested to avoid punishment of the affected dog and try response substitution instead and keep a regular daily routine to decrease unpredictability in the dog's life, in order to reduce the compulsive behavior (Luescher, 2003).

#### *2.1.1.10 Genotype*

As TC and other compulsive behavior are observed in other breeds more often than in others, a genetic predisposition is probably present (Luescher, 2003; Tiira et al., 2012). Apparent breed predispositions include flank sucking in Doberman pinchers, spinning or freezing with head under or between objects in Bull Terriers, and tail chasing in German Shepherds, Australian Cattle Dogs and Bull Terriers (Luescher, 2003). It has been suggested that dogs of herding breed often have excessive tail chasing, dogs of guarding breeds and those selected for intense focus and tenacity such as Dalmatians and Rottweilers, often had signs of hallucinations (Overall et al., 2002). There are pedigrees in the predisposed breeds that suggest a strong genetic influence with multiple affected dogs across generations and even within litters (Tiira et al., 2012).

Tiira et al. (2012) conducted their study to find out whether the candidate gene previously associated with flank sucking would also associate with TC. Recently the CDH2 gene was suggested to associate with flank sucking in Dobermans, but Tiira found no evidence of that particular gene to be associated with TC. They are currently conducting more extensive genetic analyses which might reveal the novel loci for TC.

## *2.2 Canine OCD compared to human OCD*

It has been proposed that compulsive behavior in animals share similarities with obsessive-compulsive disorders in humans (Overall et al., 2002; Tiira et al., 2012). Obsessive-compulsive disorder in all species is characterized by repetitive, ritualistic behaviors which are executed in excess of what are required for normal function. The performance of the behavior might interfere with normal, daily activities and prevent the individual from leading a normal life (Grisham et al., 2008; Overall et al., 2002).

There are several similarities between human and canine OCD, especially TC which is the priority of this study. Obsessive-compulsive disorder in humans often develops in adolescence at the onset of social maturity (Overall et al., 2002). As described earlier in this study, the same is true for dogs: about half of the dogs develop OCD (including TC) by the age of 1 (Overall et al., 2002; Moon-Fanelli et al., 2011; Tiira et. al 2012). Both humans and dogs may comprehend their behavior as abnormal and control it, even to the extent that the behavior is performed only minimally or not at all in the presence of others. A dog chasing its tail may, after frequent reproaches and corrections, stop the performance in front of audience and continue it elsewhere (Overall et al., 2002). Also, if a dog with TC or a human with OCD is physically prevented from performing the compulsion, the result in severe cases might be mounting anxiety or tension (Moon-Fanelli et al., 2011). Human OCD has been postulated to be caused by aberrant serotonin metabolism and it has also been successfully treated with clomipramine and fluoxetine, which inhibit serotonin re-uptake (Altemus et al., 1992; Yalcin 2010). The same is likely true for dogs, as the same drugs are efficient for canine OCD also (Overall et al., 2002).

The cause of compulsive disorders in both human and dog is most likely part environmental and part genetic (Grisham et al., 2008; Tiira et al., 2012). In dogs the genetic component may be even higher in certain breeds than it is in humans, as compulsive disorders are more common in certain breeds than in others (Overall et al., 2002; Tiira et al., 2012). There is evidence that early-life trauma and stressful events may be a trigger of developing OCD in humans in some cases (Grisham et al., 2008). Early life experiences, such as the age of separation from mother and the quality of maternal care, have been found to increase the risk of stereotypic behavior in dogs also (Tiira et al., 2012). There is some evidence of the effect of dietary supplements on compulsive behavior in both dogs and humans (Tiira et al., 2012), which is discussed later in more detail.

It has been hypothesized that TC and human autism share similarities (Moon-Fanelli et al., 2011). Both are presented in repeating actions in excessive or unreasonable manner and include self-injurious behavior (Moon-Fanelli et al., 2011; Overall et al., 2002; Altemus et al., 1992). Furthermore, TC-dogs have been shown to suffer from noise phobias (Moon-Fanelli et al., 2011; Tiira et al., 2012), as do autistic children, and both develop before puberty (Moon-Fanelli et al., 2011). Aggression and trance-like behavior has been associated with autism in humans (Altemus et al., 1992), as is the case in dogs. One study found TC-dogs to have episodic aggression (Moon-Fanelli et al., 2011), while another one found TC-dogs shyer than non-chasers, which might lead to aggression. It was also shown that TC-dogs have more other stereotypic behavior, such as trance-like behaviour, than non-chasers (Tiira et al., 2012). Both studies found trance-like behavior, or freezing, to be associated with TC. Both TC and autism most likely are familial in expression, with an increased risk among siblings (Tiira et al., 2012; Chabane et al., 2005). Furthermore, the gene CDH2, associated with autism in humans, was recently found to be associated with flank sucking, a compulsive disorder seen especially in Doberman pinchers. However, the same gene was not associated with TC (Tiira et al., 2012).

## *2.3 Nutritional factors in human mental disorders*

### 2.3.1 Individual micronutrients affecting the nervous system

#### *2.3.1.1 Vitamins*

2.3.1.1.1 The B vitamins

Deficiencies of various B vitamins have been proven to cause brain dysfunction (Kaplan et al., 2007). Several studies have linked low levels of folic acid ($B_9$), or folate, to symptoms of depression (Alpert et al., 2000; Bottiglieri, 1996; Tolmunen et al., 2003). A study conducted in Finland with 2 313 middle-aged men showed that those with the lowest level of folate intake were at a higher risk of being depressed. In that study they found no association between other vitamins (cobalamin [$B_{12}$], pyridoxine [$B_6$] and riboflavin [$B_2$]) and depression (Tolmunen et al., 2003). Several studies have also linked folate deficiency to poor response to antidepressants (Cornish et al., 2008; Alpert et al., 2000). A comparative, placebo-controlled study with a sample of 127 depressed patients, for example, showed that those receiving a folate supplement and fluoxetine showed a better response compared to receiving only fluoxetine (Coppen et al., 2000). Folic acid and cobalamin are required in the methylation of homocysteine to methionine and in the synthesis of S-adenosylmethionine, which is involved in numerous methylation reactions. Folate deficiency may affect central monoamine metabolism, resulting in depressive disorders (Bottiglieri, 1996).

Several studies show that chilrden with autism present low levels of pyridoxine ($B_6$). Some of the earliest studies, conducted in the late 70s and early 80s, treated autistic patients successfully with $B_6$, although these studies have later been critized (Pfeiffer et al., 1995) In 1978, Rimland, Callaway and Dreyfus conducted a double-blind placebo-controlled trial in which 11 of 15 children were classified as better on pyridoxine. Autism has also been treated successfully with a combination of pyridoxine and magnesium. A double-blind trial involving 60 autistic children found that a combination of pyridoxine and magnesium was more helpful than either one alone (Cornish et al., 2008). $B_6$ deficiency has also been related to early-onset epilepsy that is resistant to conventional anti-epileptic medications (Wang et al., 2007). It has been shown that higher total intakes of vitamins $B_6$ and $B_{12}$ were associated with a decreased likelihood of depression (Skarupski et al., 2010).

Thiamine ($B_1$) has been successfully used to treat patients with anxiety disorders (Cornish et al., 2008) and to improve mood (Kaplan et al., 2007).

2.3.1.1.2 Other vitamins

Vitamins E and C are both important antioxidants in the body and brain (Frazier et al., 2009). One study showed that patients with major depression had significantly lower serum levels of vitamin E than healthy control subjects (Maes et al., 2000). Vitamin C has been shown to protect the body from damage caused by excess vanadium in patients with a bipolar disorder. A double-blind, placebo-controlled study showed that vitamin C decreases manic symptoms in comparison to placebo (Lakhan et al., 2008).

*2.3.1.2 Minerals*

2.3.1.2.1 Calcium

It has long been known that calcium imbalance caused by hyperparathyroidism may result in anxiety, depression and cognitive function (Frazier et al., 2009). A calcium supplement has also been shown to have a positive effect on women with premenstrual syndrome symtpoms, reducing the symptoms by 50 % (Thys-Jacobs et al. 1998). When talking about calcium, it must be taken into account that calcium status is dependent on the availability of sufficient vitamin D, which means that vitamin D deficiency ultimately results in calcium deficiency (Kaplan et al., 2007).

2.3.1.2.2 Iron

Effects of early iron deficiency seem to be irreversible in terms of behavior and developmental milestones. It has been suggested that there is an early critical period of brain development during which iron deficiency can have a permanent long-term impact, resulting in cognitive and learning impairment (Youdim, 2001). Iron deficiency has also been shown to effect the dopaminergic system as iron deficient lab rats have low dopamine $D_2$ receptor levels and modified dopamine-mediated behaviors. Inspired by this, a study was conducted to compare the iron levels of medication-free schizophrenic patients and healthy controls, resulting in significantly lower iron levels in the patients than in the healthy controls (Weiser et al., 1994).

2.3.1.2.3 Zinc

It has been shown that serum zinc levels are significantly lower in patients with major depression in comparison to controls with normal mental health. Serum zinc levels were even lower in those patients who were treatment resistant (Maes et al., 1997). In a study on aggressive males an interesting finding was that the mean copper:zinc ratio was significantly higher in the aggressive males than in the control group (1,40 vs. 1,02, respectively). They also found that there was a linear relationship between the degree of zinc deficiency and the seriousness of the assaultive behavior ( Walsh et al., 1997).

Tissue concentrations of zinc, copper and iron has also been studied in Bull Terriers with lethal acrodermatitis and tail chasing behavior, however, no association was found (Uchida et al., 1997).

2.3.1.2.4 Magnesium

As discussed earlier, magnesium – $B_6$ combination has been shown to be efficient in the treatment of autism. Magnesium has also been used as an adjunctive therapy for patients with bipolar disorder, resulting in a significant decrease in medication dosages (Heiden et al., 1999). Furthermore, a combination of verapamil and magnesium oxide was found significantly more effective than a verapamil – placebo combination in manic patients (Giannini et al., 2000).

### 2.3.2 Multinutrient supplement as treatment

Previously, the dominant opinion among scientists was that mental disorders could be treated with a single vitamin or mineral, as discussed in the previous chapter, although almost two decades ago Mertz pointed out that dietary interventions of single ingredients may actually upset natural balances and create deficiences in other nutrients (Mertz, 1994). In other words, if one nutrient is deficient, a grouping of nutrients are deficient, and the level of one nutrient can affect the adequacy of others. Therefore, it would be reasonable to use a supplement containing a broad array of properly balanced micronutrients. Furthermore, even though many nutrients are important in neurological function, at present there is no compelling evidence that any given single nutrient shows more therapeutic potential than all others (Kaplan et al., 2007). It has also been speculated that as the mammalian nervous system and homeostatic mechanisms are very complex, it would be reasonable that a broad nutritional supplementation approach might be more appropriate (Kaplan et al., 2001).

A chelated vitamin-mineral supplement, EMPowerplus (EMP+) has successfully been used in several cases of mental disorders to decrease symptoms, even to the extent where pharmacological medication is no longer needed. The supplement consists of 36 ingredients: 16 minerals (calcium, iron, phosphorus, iodine, magnesium, zinc, selenium, copper, manganese, chromium, molybdenum, potassium, germanium, boron, vanadium and nickel), 14 vitamins (A, C, D, E, $B_1$, $B_2$, $B_3$, $B_6$, $B_9$, $B_{12}$, biotin [$B_7$], pantothenic acid [$B_5$], inositol and choline) 3 amino acids (*dl*-phenylalanine, glutamine and methionine) and 3 antioxidants (citrus flavonoids, grape seed from *Vitis vinitera* and leaves of *Ginko biloba*). EMP+ is a commercially available product created by David L. Hardy and Anthony F. Stephan. In 2002 their company Truehope Nutritional Support Ltd. changed the manufacturers to use methods that decreased the number of pills taken daily and improved the bioavailability of the product, thus trying to decrease the adverse effects (www.truehope.com). The studies conducted after 2002 used the new formula of EMP+.

#### *2.3.2.1 Studies and case reports*

Among the first to test EMP+ on mental disorders was Kaplan et al. (2001) who performed an open-label trial in bipolar disorder in adults. Kaplan and colleagues studied 11 patients (10 males, 1 female) aged 19-46 years for 6-21 months. Patients were assessed by their own psychiatrists and the mean symptom reduction was about 60 %. The number of psychotropic medications was reduced by more than 50 % in these patients after they began taking the supplement. The only side effect reported was nausea, especially if patients forgot to take the supplement with food. The daily dosage was 32 pills distributed into 4 doses. It needs to be taken into consideration, though, that 10 of 11 patients were men, thus generalization to women is not possible. In addition, this study didn't have a placebo control and it was an unblinded, open-label study.

Simmons (2003) described his use of EMP+ in private clinical practice. He followed 19 patients with bipolar disorders, aged 18-68, for 5-21 months. The daily dosage was 32 capsules, as was the case in Kaplan's study. Also Simmons's patients experienced gastrointestinal symptoms and nausea, especially if the pill was taken without food. By clinical global estimate, 12 of 19 patients showed marked clinical improvement, 3 showed moderate improvement and 1 showed mild improvement. 13 patients were able to discontinue psychiatric medications over a mean of 5,2 weeks (range 3-10 weeks).

Rucklidge (2009) reported her use of EMP+ in the treatment of an 18-year-old male with OCD and Asperger's syndrome who did not respond well to conventional treatments. The patient had gone through a 1-year period of cognitive behavioral therapy (CBT), during which the severity of his symptoms dropped from severe range to moderate range. A year after the termination of CBT, his scores had increased back to severe. At this time he started EMP+. No adverse effects were encountered, perhaps because he used the new version of EMP+ in which the ingredients are processed differentely. After 3 weeks of EMP+ the patient's mood had signifcantly lifted and his anxiety had dropped markedly. His OCD was present but more manageable. After 8 weeks of EMP+ treatment, the patient decided to discontinue it in order to make sure it was actually EMP+ that caused the reduction in his symptoms. 10 days after the treatment was stopped, mild symptoms began reappearing and at 3 weeks the patient experienced a significant increase in his obsessions. At 8 weeks the outcome measures were indicated that the obsessions had increased in severity and the patient decided to continue EMP+ treatment. 12 days after reinstating EMP+, the patient's scores had again dropped back to manageable. The author reports that the results had been maintained for 6 months when the article was submitted.

Popper (2001) followed a 10-year-old boy with bipolar disorder and severe temper tantrums. After 5 days of taking EMP+, all tantrums and irritability ceased. After 2 weeks the treatment was discontinued, and the symptoms reoccured after 2 days of discontinuation. The boy was then put on a different but similar supplement, which, according to parent and teacher reports, provided 60 % of the benefit noted on EMP+. When restarted on the original formula, the symptoms resumed completely.

Kaplan et al. (2004) also conducted an open-label case series to further test the impact of EMP+ in 11 children ages 8-15 with bipolar disorder, Asperger's syndrome, AD/HD, anxiety disorder and behavior disorders. 9 children completed the trial, and 88 % of them showed significant improvement.

Frazier et al. (2009) followed a 12-year-old boy diagnosed with bipolar disorder and OCD. By the age of 6 the patient experienced severe mood cycling, sadness, irritability, self-harming behavior, sleep disturbance, severe tantrums, poor peer relations, low frustration tolerance, hyperactivity and impulsive negative behaviors. At the age of 11, he began to experience auditory hallucinations, develope obsessions and compulsions and aggressive behavior. No medication, alone or combined, maintained a desirable mood balance or consistent functioning over an extended period of time. At his time his parents came across EMP+ and wanted to give it a try. After 19 days on EMP+, he was completely off all psychotropic medications and his global functioning notably increased, although he continued to experience brief periods of frustration and irritability. The patient maintained health over the subsequent 9 months before article submission.

Rucklicge, Gately and Kaplan (2010) conducted a database analysis of 358 adults with bipolar disorder. Their findings are in consensus with previous reports: 53 % of patients experienced over 50 % improvement at 6 months after starting to take EMP+. Interestingly, they found no difference between males and females. They also studied whether the effectiveness of the micronutrient treatment was influenced by psychiatric medication and found that individuals who were at a high dosage of medication had only a moderate improvement in symptoms (35 %) whereas the ones with a lower dosage or no medication experienced about 50 % improvement indicating that either use of medication interferes with the supplement's ability to benefit the patients or that the very severe ones might have partly a different etiology.

A case-control study has been conducted with conventional medication versus micronutrients management in autism. As a result, the authors found that it was possible to achieve comparable symptom management with both micronutrients and pharmaceuticals. Interestingly, micronutrient management resulted in significant advantages compared to pharmaceuticals. The patients treated with micronutrients, showed e.g. lower activity, less socail withrdrawal, less anger and irritability and fewer adverse events (Mehl-Madrona, 2010).

It should be taken into account that most of these studies and case reports lack a placebo control and are open-label, unblinded trials. Nevertheless, the results are intriguing and a randomized, placebo-controlled trial is warranted.

### 2.3.3 Why is adequate nutrition important in obsessive-compulsive disorders?

Nutrition is said to affect the structure and functioning of the brain due to the high percentage of human metabolic activity accounted by this organ. The human brain develops rapidly in the last third of pregnancy and the first 2 years of life, and has peaks of growth around ages 7, 12 and 15. In humans it is therefore reasonable to assume that during times of rapid growth there are also great demands of nutrients essential for brain development. If nutrition is inadequate, proper brain development is compromised (Benton, 2008).

It is essential to clarify the potential mechanisms of nutrient effects on mental disorders and on the structure and functioning of the brain in order for the results above to come understandable. Four explanatory models have been presented (Frazier et al., 2009; Kaplan et al., 2007). It is important to note that these potential mechanisms are not mutually exclusive or exhaustive.

First, it is suggested that mood dysregulation may result from innate metabolism malfunctions, which can have many effects such as influencing enzyme / coenzyme reactions and ultimately brain function. According to the author it has been stated that at least one third of all genetic mutations known at the present time result in an enzyme having decreased binding affinity for a coenzyme, resulting in a lower rate of reaction. In other words, there may be abnormalities in the metabolism or absorption of micronutrients and therefore inefficient use of nutrients and a higher requirement (Kaplan et al., 2007; Ames 2004).

Secondly, Kaplan et al. also present that unstable mood may be the manifestation of an already deficient methylation processes, which result in deficient enzymatic activity. Methylation reactions are of great interest, because they represent one interface between nutrients and genetic expression. Methylation is the simple process of adding a methyl group ($CH_3$) to a molecule. Simple as the process may be, it has a complex impact on our brain: methylated molecules switch on genes, complete DNA transcription, activate enzymes, regulate protein generation and synthesize neurotransmitters. The authors also speculate about the reverse possibility: psychological stress may impair methylation reactions which results in altered availability of nutrients for neurotransmitter synthesis and function (Kaplan et al., 2007; Alpert et al., 2000).

Third, nutrition deficiences may alter the phenotypic expression of a gene which may lead to mood instability. The author presents an interesting example: a study in which yellow agouti mice were given a nutrition supplement during gestation, resulting in altered coat colour and lower obesity in adults (Kaplan et al., 2007).

Fourth, mental disorders may result from long-latency effects of nutrient deficiences that alter brain development. The authors also speculate the possibility that in patients with early childhood symptoms the long-term psychological stress alters nutrient absorption (Kaplan et al., 2007).

Tiira et al (2012) studied environmental factors that affect TC, and found (N=368) that dogs that receive dietary nutrients have less tail chasing compared to dogs that do not receive nutrients. This effect was especially clear in Bull Terriers (N=109), but not in other breeds. The aim of my study is to investigate the possible association of dietary nutrient to tail chasing or other stereotypic behavior using a replicate sample of dogs.

# 3 MATERIALS AND METHODS

## *3.1 Material*

### 3.1.1 The dogs

Tiira at al. (2012) has developed a questionnaire that has questions on stereotypic behavior but also various questions on the background and daily routines of the studied dogs. Questionnaire has been advertised more to specific breeds, but dog from any breed can answer. Both dogs that have stereotypic behavior and dogs that do not have any stereotypic behavior are encouraged to answer. The study population consisted of Bull Terriers (Standard Bull Terrier [BT] and Miniature Bull Terrier [MBT]), German Shepherds (GS), Staffordshire Bull Terriers (SBT) and American Staffordshire Bull Terriers (ASBT). The data was collected using owner-completed web-based questionnaires, which were sent to breed clubs (Finnish Bull Terrier Association, German Shepherd Union Finland and Finnish Staffordshire Bull Terrier Association) and to the owners who had already given a blood sample to a dog DNA bank. The owners were invited to participate in the survey and asked to fill out the questionnaire whether their dog was a chaser or a non-chaser.

The questionnare consisted of a series of questions including general history, environmental factors, diet, tail chasing history and the presence of possible compulsive behaviours, such as licking, excessive drinking or fly-snapping. In addition, there were questions about the age of dog' s separation from its mother, the quality of maternal care and dietary supplements. The owners were asked whether their dogs received dietary supplements and if so, what supplements and how often (1 = sometimes, 2 = regularly). All dogs who received dietary supplements, were chosen for this study; altogether 156 dogs from four breeds (BT / MBT: 3 females and 3 males; GS: 2 females and 15 males [1 sex unknown]; SBT: 57 females and 44 males [1 sex unknown]; ASBT: 19 females and 13 males). See *Figures 1 and 2.*

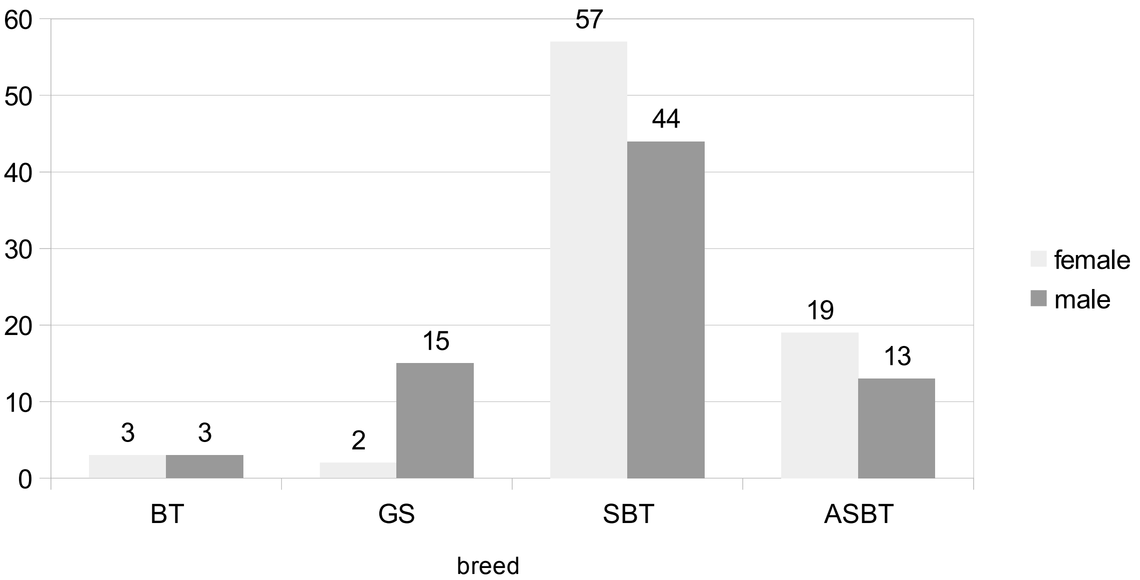


*Figure 1. Sex and breed of the dogs who received micronutrients.*

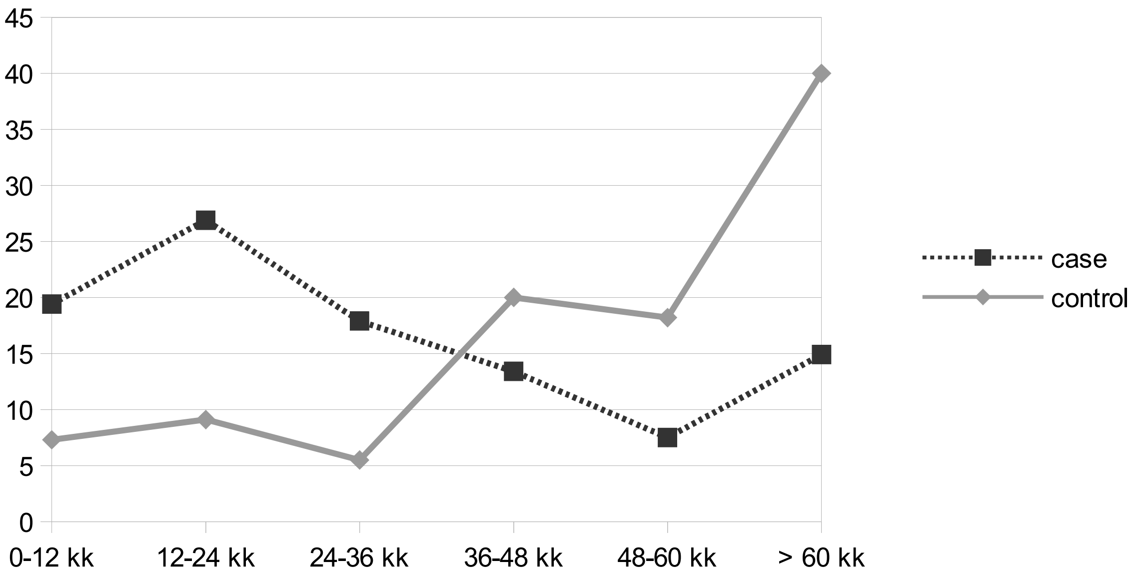


*Figure 2. Ages of the case and control groups all breeds combined, n = 122.*

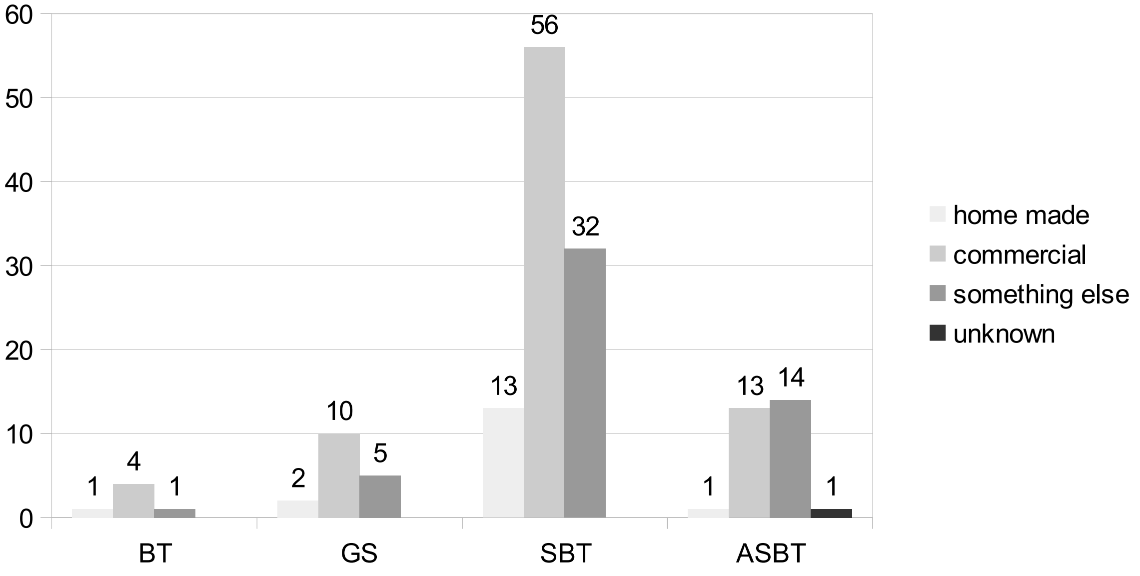


*Figure 3. The type of food the dogs ate shown by breed.*

As a part of the first questionnaire the owners were asked to report the type of food their dog received. Five categories were given: *1) home made – leftovers, 2) home made – specially for the dog, 3) commercial – pet store, 4) commercial – super market or 5) something else.* Since there was only one dog receiving *commercial – super market* and no dogs receiving *home made – leftovers,* the main categories were re-grouped as follows: *1) home made (both categories), 2) commercial* (both categories) and 3) *something else,* which includes raw-food diet and a combination of home made, commercial and / or raw-food diet. See *Figure 3.*

As a measure of frequency and intensity of tail chasing Tiira et al. used a variable called $TC_{index}$, which was based on the owners' answers. $TC_{index}$ (0-12) is a sum of the numerical answers to the questions "Does your dog chase its tail?" (7 categories: "never", "once or twice in lifetime", "less than once a month to once a year", "less than once a week to once a month", "every 2 days to once a week", "daily" and "multiple times a day"), "On average, how much time does your dog spend on chasing its tail on a normal day?" (0 min, 0-30 min, 30 min – 1 hour, 1-2 hours, 2-3 hours, 3-5 hours and more than 5 hours) and "On average, how long does one tail chasing bout last?" (0-5 s, 5-30 s, 30 s – 1 min, 1-5 min, 5-10 min, 10-15 min, 15-30 min, 30 min – 1 hour, 1-2 hours, 2 hours or more). Dogs with no history of tail chasing were considered as controls ($TC_{index}=0$). In the current study, dogs were divided into two groups: 1) case ($TC_{index}\geq 2$) and 2) control ($TC_{index}=0$). Mild cases ($TC_{index}=1$) were excluded from the analyses. Cases were coded as *statusTC=1* and controls were coded as *statusTC=0.* Case and control groups included a total of 131 dogs. See *Figure 4.*

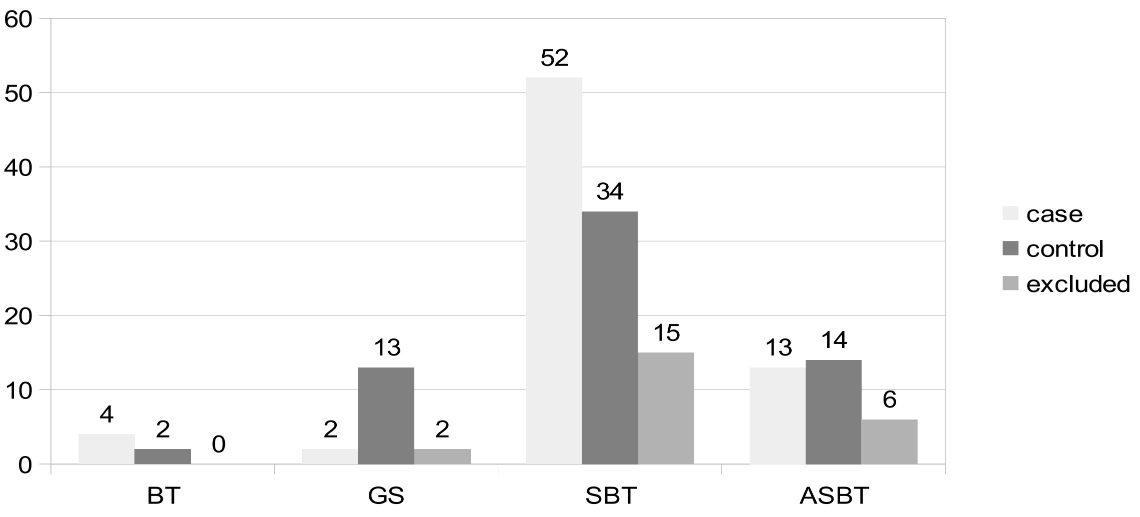


*Figure 4. StatusTC by breed, n = 156.*

Other stereotypic behaviour was also asked about in the questionnare. The variable $L_{index}$ for licking is a sum of the numerical answers to the questions “Does your dog lick?”, “On average, how much time does your dog spend on licking on a normal day?” and “On average, how much time does your dog spend on licking during one episode?”. The categories were as mentioned above. Dogs with $L_{index} \geq 10$ were coded as *statusLICK=1* whereas dogs who had $L_{index} < 10$ were coded as *statusLICK=0.* This information was available in all of the 156 dogs. See *Figure 5.*

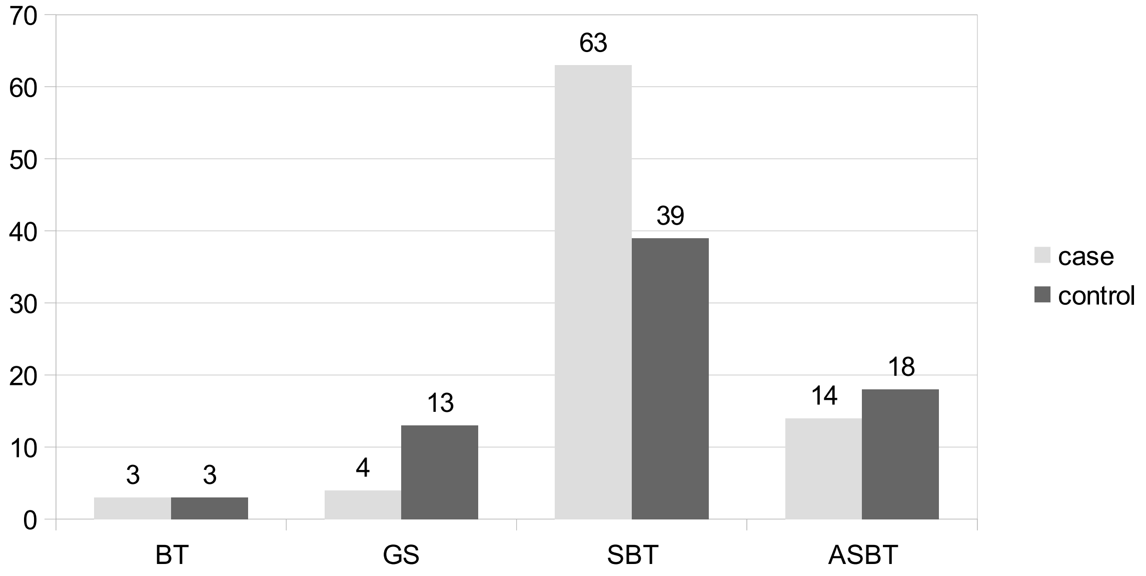


*Figure 5. StatusLICK by breed, n = 156.*

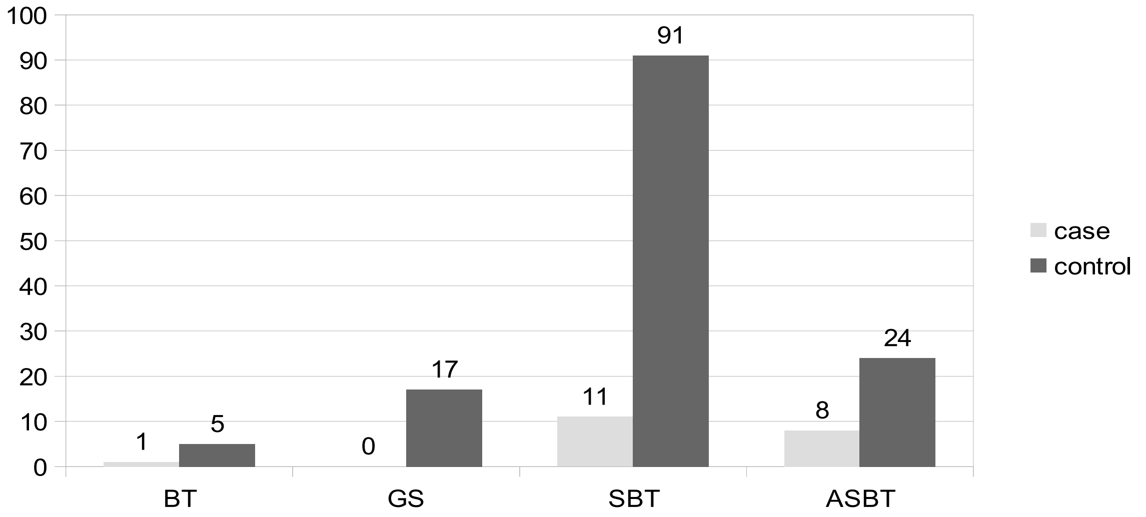


*Figure 6. StatusFS by breed, n = 156.*

The variable $FS_{index}$ for fly snapping is a sum of the numerical answers to the questions "Does your dog snap flies?", "On average, how much time does your dog spend on fly snapping on a normal day?" and "On average, how long does one bout of fly snapping last?". Dogs with $FS_{index} \geq 1$ were coded as *statusFS=1* and dogs with $FS_{index} < 1$ were coded as *statusFS=0.* This information was available in all cases. See *Figure 6.*

The variable $ED_{index}$ for excessive drinking is a sum of the numerical answers to the questions "How many times a day does your dog go to its water bowl (to drink or to stare)?" from 0 to 12 times or more, "Have you had to restrict your dog's drinking?" (yes or no, multiplied by 10), "On average, how much time does your dog spend on drinking on a normal day?" from 0 minutes to 5 hours or more and "On average, how much time does your dog spend on drinking during one episode?" from 0 seconds to 2 hours or more. Dogs with $ED_{index} \geq 10$ were coded as *statusED=1* and dogs with $ED_{index} < 10$ were coded as *statusED=0.* This information was available in 123 cases. See *Figure 7.*

All of the stereotypes mentioned above were combined to one variable, $TOT_{stereo}$, which is simply the total number of stereotypes the dog has. Licking, drinking and fly snapping are considered to be stereotypes, if $L_{index} > 10$, $ED_{index} > 10$ and $FS_{index} > 1$. *TOTstereo* was calculated for 104 dogs as that was the number of dogs all the required information was available for. See *Figure 8.*

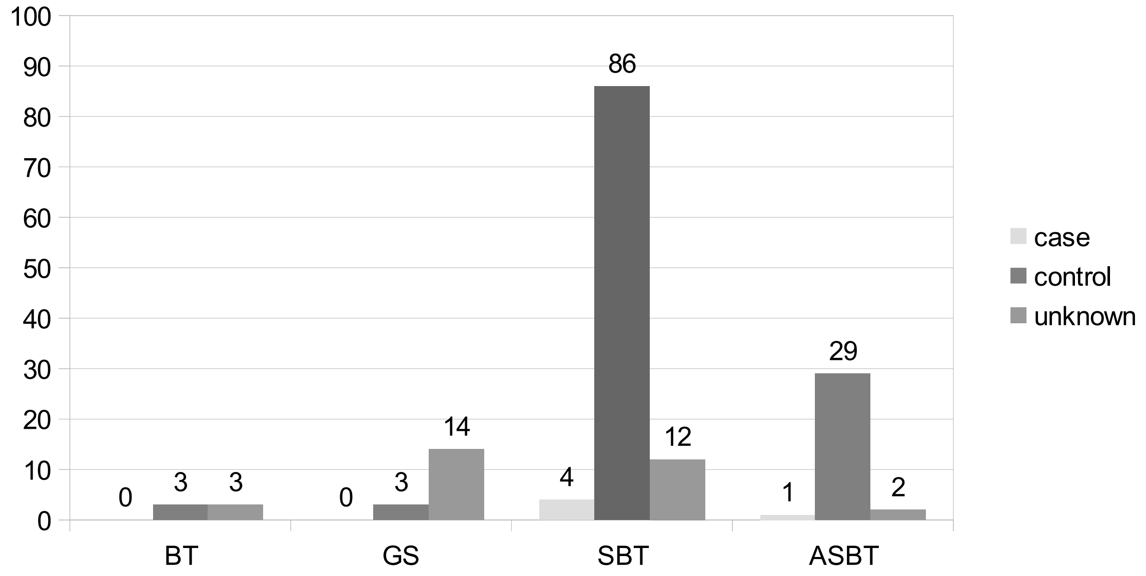


*Figure 7. StatusED by breed, n = 156.*

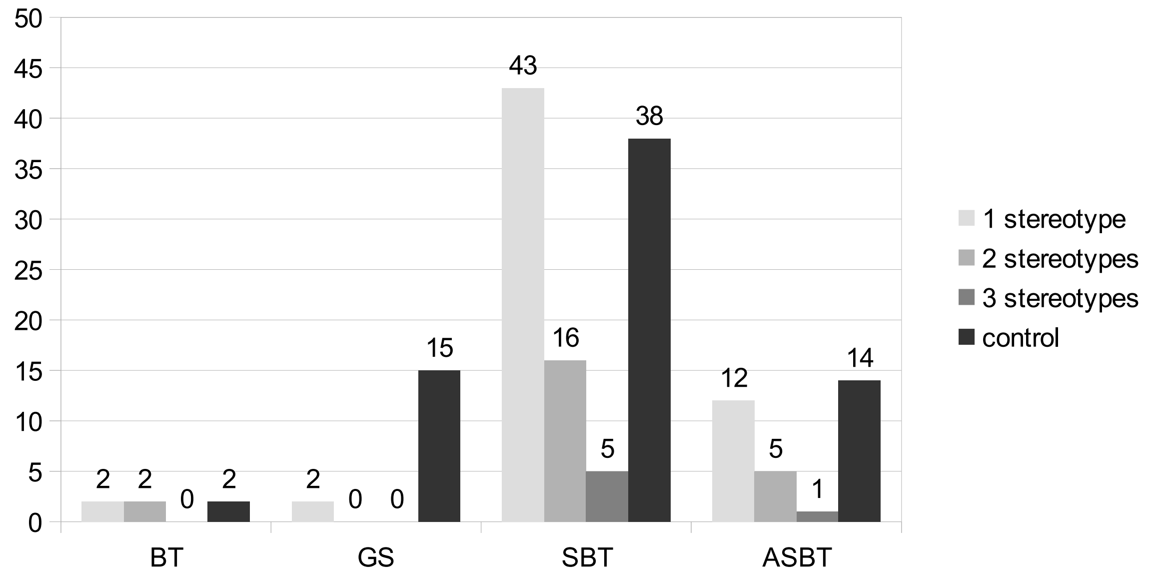


*Figure 8. Total number of stereotypes by breed, n = 104.*

### 3.1.2 The supplementary groups

In the questionnare, 156 dogs received dietary supplements. The owners were asked the name of the supplement their dogs received, then the specific micronutrient content of the supplements were defined using internet search engines. The micronutrients were divided

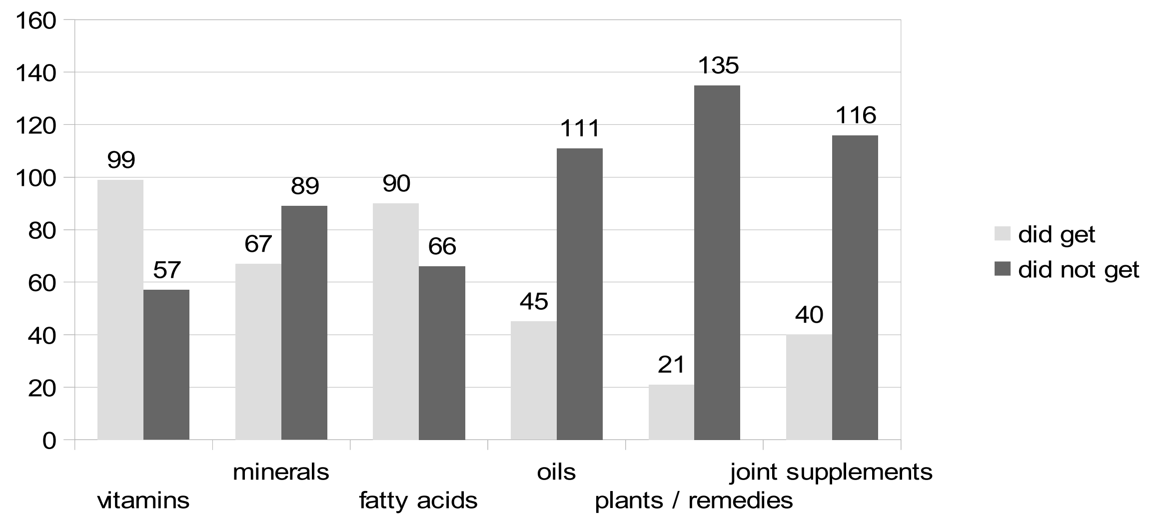


*Figure 9. Reception of micronutrients, all breeds.*

into minerals (Bo, I, Zn, Mn, Cu, Mo, K, $CaPO_4$, Ca, Cl, Na, P, Mg, Fe, Si, Sr, V, Se, S, Co, Cd, Cr, Hg, Sn and Pb), vitamins (A, β-carotene, $B_1$, $B_2$, $B_3$, $B_5$, $B_6$, $B_7$, $B_8$, $B_9$, $B_{12}$, C, D, $D_3$,E, H, K, milk powder, lactose, seaweed, E. faecium, inositol, pectin, DL-methionine), oils (hemp oil, canola oil, flax oil, salmon oil, cod liver oil) which were also divided into fatty acids, fatty acids divided into omega-3 (ALA, DHA, DPA, EPA, ETA), omega-6 (AA, LA, GLA), omega-7 and omega-9, , plants / remedies (turmeric extract, green tea extract, yucca) and joint supplements (chondroitin sulphate, glucosamine, MSM). If the dog received a certain micronutrient it was coded as 1, and 0 if it did not receive it. If the dog owner had not specified the seaweed their dog received, it was considered to be Islamer. If it was unknown which oil the dog received, it was considered just as "oil".

Each micronutrient group (minerals, vitamins, oils, fatty acids, plants / remedies and joint supplements) was also presented in binary form. If the dog received any micronutrient of the certain group, it was coded as 1 and if not, it was coded as 0. The groups were also presented in a sum form: if the dog received 6 different vitamins, it was coded as 6.

## *3.2 Methods*

### 3.2.1 Statistical analysis

The statistical analysis was performed using the IBM SPSS 22 program.The dogs from the study by Tiira et al. were divided into two groups containing all breeds: 1) case ($TC_{index} \geq 2$) and 2) control ($TC_{index}=0$). The data was first analysed with a chi-square test. A case-control setup was used to compare differencies between tail chasers ($TC_{index} \geq 2$) and controls ($TC_{index}=0$), leaving the mild chasers ($TC_{index}=1$) out. There was no significant correlation between dietary supplements and tail chasing. Mild chasers were left out the analyses, because their tail chasing might not be significant.

Chi-square test was performed to find out if there was an association of tail chasing with any group of supplements. Both tail chasing and supplement groups were analysed as binary values, which means the dog either had tail chasing or it did not, and the dog either received micronutrients from a supplement group (minerals, vitamins, oils, fatty acids, plants / remedies and joint supplements) or it did not. The supplement groups that seemed to have an association with tail chasing were then analysed separately as individual supplements, e.g. Mg, Zn etc. to find out which specific supplement was the significant one. This was done by Fisher's exact test.

The same was done with licking, excessive drinking, fly snapping, and finally with all stereotypes put together as one value.

None of the groups analyzed were normally distributed.

# 4 RESULTS

The only supplement group that differed between dogs that had tail chasing compared to dogs with no tail chasing observed was joint supplements (p = 0,024). The dogs that chased their tail received less joint supplements. When joint supplements were further analyzed, dogs that received glucosaminoglycan (p = 0,060) seemed to have a non-significant tendency to chase their tail less than those not receiveing any.

Vitamins (p = 0,078), fatty acids (p = 0,080) and oils (p = 0,078) had non-significant association with licking. Dogs that received vitamins seemed to lick less than those not receiving any, whereas dogs that received fatty acids or oils seemed to lick more than those not receiving any. Vitamins were further analyzed, and dogs that received β-carotene (p = 0,075) or vitamin $B_7$ (p = 0,081) seemed to have a non-significant and dogs that received vitamin H (p = 0,012) a significant tendency to lick less than those not receiving any. The most significant fatty acids seemed to be omega 3 (p = 0,080) and omega-6 (p = 0,113). The most significant oil was canola oil (p = 0,165). Dogs that received omega-3 or -6, or canola oil, licked more than those not receiving any of those.

There was no statistically significant association of any of the supplement groups with either fly snapping or excessive drinking.

The possible assocation of supplements with stereotypic behaviour was also analysed by using $TOT_{stereo}$ as a binary variable. The results were in-line with the previous analyses: those dogs who had stereotypes of any sort, received more fatty acids (p = 0,037) or oils (p = 0,045), whereas the dogs with no stereotypes received more joint supplements (p = 0,046).

The previous results showed an association of fatty acids with stereotypic behaviour. This was analysed further by comparing the different fatty acids and it revealed that dogs receiving omega-6 had more stereotypic behaviour (p = 0,046) than those not receiving any. This seemed to be the case especially with omega-6 LA (p = 0,048) and GLA (p = 0,029). The association of oils with stereotypic behaviour was analysed the same way, and it revealed hemp oil to have a significant (p = 0,038) and flex oil to have a non-significant (p = 0,054) associaton to any stereotypic behaviour.

No bonferroni correction was done. None of the results is significant, if bonferroni correction was done.

# 5 DISCUSSION

Dogs suffer from various types of stereotypic behaviour such as tail chasing, spinning, flank sucking, fly snapping and catching light reflections or shadows. The etiologies of stereotypic behaviours still remain largely unknown, yet there are several suspected components that might contribute to these types of behaviours. As TC and other compulsive behavior are observed in other breeds more often than in others, a genetic predisposition is probably present (Luescher, 2003; Tiira et al., 2012). Recently, the CDH2 gene was suggested to associate with flank sucking in Dobermans (Dodman et al., 2010). The same gene has been associated with autism in humans. Tiira found no evidence of that particular gene to be associated with TC. Tiira et al. (2012) did find a statistically significant association between TC and dietary nutrients. The dogs who received dietary nutrients had less TC compared to those who did not receive any. The specific micronutrient was vitamin $B_6$, which, combined to Mg, has also been used to treat autism in humans.

In this study, no associaton of vitamins with TC was found. Instead, the only supplement group that had significant association with tail chasing was joint supplements, especially glucosaminoglycan. The dogs that chased their tail received less joint supplements. The population of tail chasers in this study was younger than that of non-chasers, which could be one explanation to why they received less joint supplements than the control group. Older dogs may be stiff at gait or even have symptoms of arthrosis, which is why owners may give them joint supplements.

Vitamins, fatty acids and oils had a non-significant association with licking. Dogs that received vitamins seemed to lick less than those not receiving any, whereas dogs that received omega-3 or omega-6, or canola oil seemed to lick more than those not receiving any. It is likely that owners give oil or fatty acid products to their dogs thinking there might be a skin problem and that is why the dogs lick. Giving oil to licking dogs might actually be more a consequence than the original cause, especially given that Staffordshire Bull Terriers are predisposed to allergies and other skin problems.

It also seemed that dogs receiving omega-6 fatty acids or hemp oil had a non-significant tendency to chase their tail more than those not receiving any. Furthermore, those dogs who had stereotypes of any sort, received more fatty acids and oils, whereas the dogs with no stereotypes received more joint supplements. This might be due to Tiira's finding that dogs with TC also had other stereotypic behaviour such as licking (Tiira et al., 2012).

There was no statistically significant association of any of the supplement groups with either fly snapping or excessive drinking. This is because the population of fly snappers and excessive drinker was too small to be statistically relevant.

The results of this study differ from those of Tiira et al.'s. In this study, no associaton of vitamin $B_6$ and Mg with tail chasing was found. Tiira's study population consisted mostly of Bull Terriers, among which the association was found, whereas the population of this study consisted mainly of Staffordshire Bull Terriers and included only a few Bull Terriers. Secondly, it is only known whether the owner feeds their dog dietary supplements "sometimes" or "regularly". The amount of the supplement fed is not known, and neither is the actual frequency the supplement is given. When asked which supplement, some owners only answered "oil" or "seaweed", not mentioning the spesific name of the product. Also, no detailed information of the basic food was available, so it was not possible to calculate the actual amount of nutrients ingested. That is, it is not fully possible to reliably compare these dogs to each other.

### *5.1 Conclusion*

All in all, more research is needed. Human autism and OCD share multiple similarities with canine stereotypic behaviour, and there is strong evidence of treatment of human OCD and autism with a multinutrient supplement. So why couldn't canine compulsive disorders be treated with micronutrients aswell? It would certainly be interesting to give either a multinutrient supplement or a combination of $B_6$ and Mg to tail chasers and see if there is any changes in their behaviour. A controlled, unbiased clinical trial or a cohort study would perhaps give us more answers.

## 6 ACKNOWLEDGEMENTS

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