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SPECIFIC CARBOHYDRATE DIET (SCD/GAPS) AND DIETARY SUPPLEMENTS FOR CHILDREN WITH AUTISTIC SPECTRUM DISORDER

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*The objective of the study was to investigate the potential of a specific carbohydrate diet and selected dietary supplements in reducing some autistic spectrum disorder (ASD) symptoms in children. This was a quantitative, non-blinded, non-randomised three-month pilot study of a dietary and nutritional intervention. The study participants were 17 children from Latvia and the United Kingdom with a diagnosis of ASD or autistic symptoms waiting to be diagnosed (intervention group n = 10, control group n = 7). The intervention group received a specific carbohydrate dietary plan — Specific Carbohydrate Diet / Gut and Psychology Syndrome diet (SCD/GAPS) — and a few dietary supplements (omega-3 essential fatty acids, ascorbyl-palmitate, probiotics, vitamin D, and vitamin C). Family compliance to the dietary guidelines was 40–80%. Autistic and digestive symptoms were evaluated by parents using validated questionnaires. By the end of the study, gastrointestinal symptoms decreased in both groups (*p *= 0.01 for the intervention group,* p *= 0.02 for the control group), especially abdominal pain and bloating. The Overall Autism Treatment Evaluation Checklist (ATEC) score decreased by 23% in the intervention group (*p *= 0.05), with the largest improvement in Socialising (*p *= 0.03) and Health/Behaviour (*p *= 0.02) aspects. The Aberrant Behaviour Checklist (ABC) score decreased by 29% in the intervention group (*p *= 0.01), with the largest improvement in Irritability (*p *< 0.01) and Hyperactivity (*p *= 0.02) subcategories. Overall Parent Global Impressions — Revised-2 (PGI-2) evaluation showed a 43% improvement in the intervention group in comparison to 14% in the control group,* p *= 0.02. The specific carbohydrate diet (SCD/GAPS) and supplements were found to be a safe and effective approach for reducing some symptoms of ASD in children.*

Keywords: *autism, low carbohydrate diet, gut and psychology syndrome, gut microbiome, gut-brain connection.*

INTRODUCTION

According to the American Psychiatric Association and *Diagnostic and Statistical Manual of Mental Disorders* (5th Edition), autism spectrum disorder (ASD) is a complex developmental condition that involves persistent challenges in social interaction, speech and nonverbal communication, and restricted/repetitive behaviours. The expression of ASD and the severity of symptoms are different in each person (Diagnostic and Statistical Manual of Mental Disorders, DSM-V, 2013). Most children with ASD are not diagnosed until after age three (Barbaro and Dissanayake, 2009; Shattuck *et al*., 2009). The causes of autism are multifactorial, and its aetiology is complex, with both environment and genetic factors playing a significant influence. According to the Centres for Disease Control and Prevention, USA (CDC) data, ASD prevalence is one in 54 children in the United States (CDC, 2016). ASD is about four times more common among boys than among girls (CDC, 2016). The estimated prevalence of ASD in children in Europe is from five to 31 children in 1000 (Chiarotti and Venerosi, 2020).

In addition to neurological, developmental, and communication difficulties most autistic children typically have gastrointestinal tract (GIT) problems, gut dysbiosis, digestion issues and significant nutritional deficiencies (Wasilewska and Klukowski, 2015). Studies show that up to 91% of children with ASD suffer from various gastrointestinal disorders (Rose *et al*., 2017). Children with ASD very often have irritable bowel syndrome (IBS), an altered gut microbiome (dysbiosis), food allergies and intolerances, constipation, diarrhoea, abdominal pain, and increased flatulence leading to bloating (Buie *et al*., 2010; Wasilewska and Klukowski, 2015). Gut symptoms were found to strongly correlate with ASD severity (Adams *et al.*, 2011c). GIT symptoms together with selective eating habits were shown to be the cause of significant nutritional deficiencies for autistic children (Adams *et al.*, 2011a; 2011b). All these symptoms affect the well-being of children during the day and the quality of sleep at night, which directly affect children's cognitive function and stress levels.

The gut-brain axis is a bidirectional communication between the gut and the brain. Scientists have concluded that, among other causes, ASD could be related to gut dysbiosis and disturbances in the gut-brain axis communication (Wasilewska and Klukowski, 2015). Gastrointestinal dysfunction and symptoms of GIT can be related to hyperactivity, attention deficit, irritability, self-harm, behaviour problems, sleep disturbances, and other neurological symptoms in children with ASD via the gut-brain axis (Horvath and Perman, 2002). It has been shown that by addressing these underlying digestive conditions and healing the gut, one can alleviate expression of some autistic symptoms, such as behaviour problems, language impairments, irritability, sleep problems, and hyperactivity (Wasilewska and Klukowski, 2015). There are studies showing that with dietary changes, usually in combination with nutritional supplements, some ASD symptoms can be significantly decreased (Adams *et al*., 2018). In several nutritional and dietary intervention studies, it has been demonstrated that by addressing underlying digestive conditions, one can alleviate expression of some autistic symptoms (Adams *et al*., 2018; Lange *et al*., 2015).

Some studies have already investigated the effect of nutrition interventions for ASD in children. For example, the Gluten-Free / Casein-Free (GF/CF) diet was the most frequently used dietary intervention for ASD (Cubala-Kucharska, 2010; Piwowarczyk *et al*., 2018; Washnieski *et al*., 2010, Whiteley *et al*., 2012). A GF/CF diet recommends excluding products containing gluten (bread, pasta, pizza, biscuits, crackers, cakes, cereals made from wheat, barley, and rye) and dairy products containing casein (milk, cheese, yoghurt, ice cream, and sauces). In a study performed in the United Kingdom, parents who followed a GF/CF diet for children with ASD reported significant improvements, including gastrointestinal function, concentration, and attention span of the children (Lange *et al*., 2015). In a study by Adams *et al.* (2018), the results showed a 28% reduction in ASD symptoms observed in the treatment group compared to 6% reduction in the non-treatment group (Adams *et al.,* 2018).

Another type of diet, the specific carbohydrate diet (SCD) was developed in the early 1900s by Dr Sydney Valentine Haas, an American paediatrician who used elimination of carbohydrates for paediatric inflammatory bowel disease and the condition known as celiac disease toady (Haas, 1951). Haas treated over 600 cases of celiac disease with his Specific Carbohydrate Diet. Later, SCD was studied and further developed by Elaine Gottshall (Gottshall, 1986) and described in her book *Breaking the Vicious Cycle: Intestinal Health Through Diet*. Gottschall proposed the digestion-gut-autism connection (Gottshall, 2004), and this approach was further developed by Dr Natasha Campbell-McBride in her book *Gut and Psychology Syndrome: Natural Treatment for Autism, Dyspraxia, A.D.D., Dyslexia, A.D.H.D., Depression, Schizophrenia* (Campbell-McBride, 2004). In this book, the concept of connection between the gut health and brain functions was established as the Gut and Psychology Syndrome (GAPS) (Campbell-McBride, 2004).

The main principles of the SCD and GAPS diet are very similar and can therefore be unified in the SCD/GAPS diet. The SCD/GAPS diet suggests excluding complex carbohydrates from the diet, namely, all products containing disaccharides and polysaccharides. Therefore, avoiding sugar (sucrose), grains (starch) and starchy vegetables, non-fermented milk products (lactose) and processed food is recommended. The rationale for the SCD/GAPS diet is based on evidence that autistic people are unable to properly digest and assimilate complex carbohydrates. Incompletely digested carbohydrate molecules accumulate in the gut, where they ferment and feed pathogenic bacteria. By removing these complex carbohydrates from the diet for some time, the digestive system is given a chance to recover (Campbell-McBride, 2004). Simultaneously, the SCD/GAPS is a nutrient-rich diet, as it includes meat broths, soups, fermented foods containing probiotic bacteria, good fats (eggs, butter, olive oil, coconut oil, avocado, animal fats, etc.), allowed vegetables and fruits, meat, fish, nuts, and seeds, all of which are essential for human health (Campbell-McBride, 2004).

Although some studies on the SCD/GAPS diet were performed in the past, is has not been extensively studied regarding its effects on ASD in children. The objective of this study was to investigate the potential of the SCD/GAPS diet, complemented with vitamins/supplements, to see if this approach could improve gastrointestinal health in children with ASD, as well as reduce some typical ASD symptoms such as hyperactivity, irritability, and sensory sensitivity. We hypothesised that normalising the gut microbiome and optimising the communication between the gut and the brain can help to improve the brain function in children with ASD. Thus, addressing the dysfunction of GIT with an appropriate diet and supplements will alleviate not only digestive symptoms, but also the expression of ASD symptoms in these children.

MATERIALS AND METHODS

Study design and participants. This was a quantitative, not-blinded, non-randomised three-month interventional study of nutritional and dietary treatment. The participants were 17 children (2 to 18 years old) from Latvia and the United Kingdom with an already established diagnosis of ASD or autistic symptoms waiting to be diagnosed (intervention group n = 10, control group n = 7). Diagnostics of ASD was not performed during the study. The presence of autistic symptoms in children was determined through a primary questionnaire about the child's medical history. All 17 children whose parents applied to the study were enrolled. Allocation of children to both groups was voluntarily chosen by parents. One child was excluded from the analysis of the results as his family did not comply with the guidelines of the control group. The design of the study is shown in Figure 1.

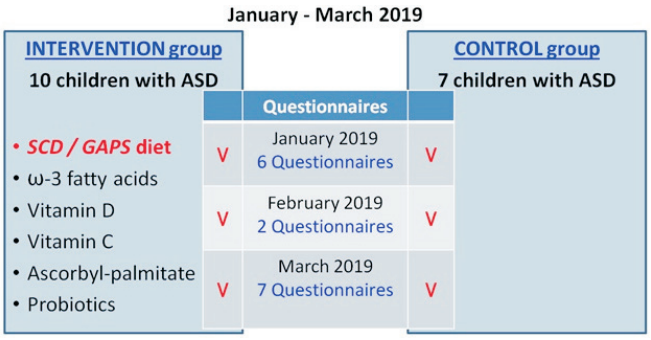


Fig. 1. Design of the study.

This study applied a specific carbohydrate dietary plan — Specific Carbohydrate Diet / Gut and Psychology Syndrome diet (SCD/GAPS). Compliance to the diet each month was self-evaluated by the parents (in %). Several vitamins and dietary supplements were suggested for children with ASD in this study — omega-3 fatty acids (Lysi Fish oil or ZinZino Balance oil), ascorbyl-palmitate (Now Foods), probiotics (Lacto 7, Vitabalans Oy, Finland), vitamin D3, and vitamin C. Vitamin C was sponsored by Lotos Pharma (Latvia), and vitamin D3 was sponsored by Innopharma (Denmark). The dosage of vitamins and supplements was calculated according to the child's age and weight.

Mental symptoms (behaviour, hyperactivity, aggression, attention deficit, eye contact, language perception, and speech), social interaction, everyday skills, sensory senses, and other symptoms were evaluated by parents two times during the study (at baseline in January, and by the end of the study in March 2019), using the questionnaires described below, with the exception of the Parent Global Impression – Revised-2 (PGI-2) and 6-Gastrointestinal Severity Index (6-GSI). To measure levels of improvement from zero or no change point (at baseline in January), PGI-2 was used in February (middle of the study) and March. GIT symptoms were evaluated by parents using the 6-GSI questionnaire three times during the study (in January, February, and March) to allow for monitoring of changes in GIT symptoms.

Study instruments. Autistic and digestive symptoms of children were evaluated by parents using seven validated questionnaires:

– 6-GSI – 6-Gastrointestinal Severity Index

– ATEC – Autism Treatment Evaluation Checklist

– MSEC – Mental Synthesis Evaluation Checklist (data not shown in this paper)

– ASD – Autistic Spectrum Disorder Assessment Scale

– ABC – Aberrant Behaviour Checklist

– SSP – Short Sensory Profile

– PGI-2 – Parent Global Impression – Revised-2

Gastrointestinal Severity Index (6-GSI). GIT symptoms were evaluated by a modified version of the Gastrointestinal Severity Index (6-GSI questionnaire), similarly as in the studies by Adams *et al.* (2011c; 2018). Constipation, diarrhoea, bloating, abdominal pain, and consistency and smell of faeces were evaluated by parents. The maximal number of points was 12, the minimal (no symptoms) was zero points. As a result, the higher the score, the more GIT symptoms the child had. Children with no GIT symptoms (6-GSI score = zero) at the start of the study were excluded from the 6-GSI data analysis.

Autism Treatment Evaluation Checklist (ATEC) is one of the most widely used questionnaires for comparison of ASD indicators over a longer period. The number of ATEC points can be used as a guide to assess the severity of ASD expression (the higher the ATEC score, the more severe is ASD expression), but not for diagnosis. The ATEC questionnaire (Edelson, 2019; Rimland and Edelson, 2016) contains 77 questions divided into four subcategories:

– Speech / Communication (14 questions)

– Sociability (20 questions)

– Sensory / Cognitive Awareness (18 questions)

– Health / Physical Behaviour (25 questions)

The ATEC in Latvian has been now added to the www.autism.org website.

The Autistic Spectrum Disorder (ASD) assessment scale (Grossmann, 2019) allows parents to assess children's behaviour, language, social interaction, and ability to integrate in the society. In the case of an improvement, a decrease in ASD assessment scale is expected.

The Aberrant Behaviour Checklist (ABC) (Schmidt *et al.*, 2013) is a rating scale that measures the severity of problematic behaviours commonly observed in individuals with intellectual and developmental disabilities. Fifty-eight symptoms are divided into five subscales: irritability, leth-

argy, stereotypy, hyperactivity, and inappropriate speech. The higher the ABC score, the more behaviour problems the child has. In the case of positive changes in the child's behaviour, a decrease in ABC score is expected.

Short Sensory Profile (SSP) assesses children's sensory sensitivity to the environment — taste, smell, sound, light, movement, as well as tactile sensation (McIntosh *et al.*, 1999). The SSP consists of 38 questions divided into seven subcategories (Tomchek and Dunn, 2007). This questionnaire gives a higher score if there are fewer sensory problems, so increase in score is expected with improvement of child's condition. The total number of points can be from 38 (minimum) to 190 (maximum).

Parent Global Impression – Revised-2 (PGI-2) questionnaire (Adams *et al.,* 2011c; 2018) assesses changes in 17 symptoms, such as language, attention span, cognition, GIT symptoms, sleep, behaviour, sociability, sensitivity, hyperactivity, aggression, eye contact, mood, and anxiety. The rating was done using a seven-point scale: –3 (much worse), –2 (worse), –1 (slightly worse), 0 (no change), 1 (slightly better), 2 (better) and 3 (much better). The average PGI-2 score in each group was calculated.

The validation of these seven questionnaires in Latvian was performed for the purpose of this study and involved the following steps:

1) obtaining of the original questionnaires in English;

2) translation of questionnaires into Latvian;

3) back translation of questionnaires from Latvian into English;

4) revision of the translated questionnaires by a certified translator and comparison of two translations in order to evaluate the content and to determine whether the meaning of the questions did not disappear;

5) decision of a certified translator and subsequent improvements according to that decision;

6) filling in the questionnaires by an independent person that was not involved in the study to assess whether the questions could be understood unambiguously;

7) after all final improvement suggestions from the independent person have been included into the questionnaires, the validation of questionnaires was considered to be fully performed.

Statistical analysis. For each group of participants (intervention group, control group), the means and standard deviations were calculated for each questionnaire. Differences between study groups were calculated using a *t*-test. As the working hypothesis was that the improvement for the intervention group would be greater than for the control group, a one-sided unpaired *t*-test assuming unequal variance was used for comparison between the two study groups at the same time. A paired *t*-test was used to compare the results within each group at two time points of the study. A *p* value of 0.05 or lower was assumed as statistically significant.

The ethical approval from the Ethics Committee of the Institute of Cardiology and Regenerative Medicine, University of Latvia, was obtained for this study, and informed consent was obtained from all the participants.

RESULTS

Ten children with ASD who followed the SCD/GAPS diet for three months and used the above-mentioned vitamins/supplements, and seven children with ASD who did not change their diet were enrolled in the study. There were seven (out of ten) children with ASD diagnosis in the intervention group, and four (out of seven) children with ASD diagnosis in the control group. Parents reported 40–80% compliance with the SCD/GAPS dietary guidelines and demonstrated 100% compliance in completing the questionnaires.

6-Gastrointestinal Severity Index (6-GSI). According to the 6-GSI questionnaire, almost all children in the study (15 out of 17) had gastrointestinal symptoms: flatulence, constipation, unformed stool, and abdominal pain. About 50% of children enrolled in the study had constipation and bloating, one-third of them had unformed stool, and 20% of children had abdominal pain. Gastrointestinal symptoms improved in both groups (Fig. 2), showing statistically significant difference between time points (p = 0.01 for the intervention group, and p = 0.02 for the control group). The largest difference was observed for abdominal pain and bloating.

Autism Treatment Evaluation Checklist (ATEC). By the end of the study, the overall ATEC score decreased by 23% in the intervention group, with the largest improvement in Socialising (p = 0.03) and Health/Behaviour (p = 0.02) symptom subcategories. In the control group the ATEC reduction was 6% (p = 0.26). The ATEC score difference be-

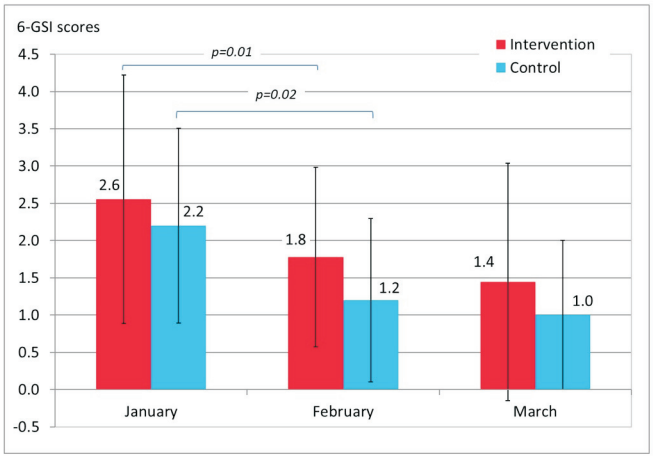


Fig. 2. Total 6-Gastrointestinal Severity Index (6-GSI) scores during the study. Data from the 6-GSI questionnaire. Higher scores indicate greater severity. Only children with symptoms present are included here (intervention group n = 9, control group n = 5). Error bars represent standard deviations.

tween time points was statistically significant for the intervention group (p = 0.05) (Fig. 3).

The Autism Spectrum Disorder Assessment Scale (ASD). At the beginning of the study, a statistically significant difference in ASD (p = 0.05) between the intervention and control group was observed: children in the intervention group had a higher ASD score than children in the control group. The ASD assessment scale showed a 25% reduction of autistic symptoms in the intervention group at the end of the study (p = 0.01), and practically no change (1%, p = 0.5) in the control group (Fig. 4). The results of the ASD Assessment Scale for the intervention group (Fig. 4) were in line with changes in the ATEC score (Fig. 3).

Aberrant Behaviour Checklist (ABC). At the beginning of the study, a statistically non-significant difference in ABC (p = 0.06) between the intervention and control group was observed, with children in the intervention group having a higher ABC score for aberrant behaviour. In three months, the ABC score decreased by 29% (p < 0.01) in the intervention group, with the largest improvement in the Irritability (p < 0.01) and Hyperactivity (p = 0.02) categories, while there were practically no changes in the control group (Fig. 5).

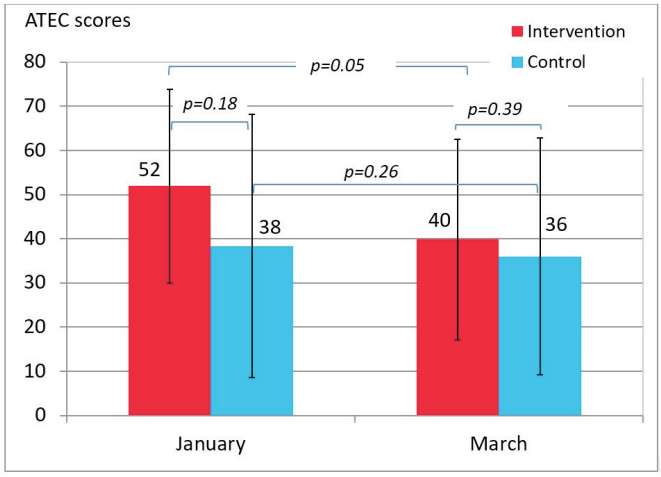


Fig. 3. Total Autism Treatment Evaluation Checklist (ATEC) scores at the beginning and end of the study. Data from the ATEC questionnaire. Higher scores indicate greater severity. Intervention group n = 10, control group n = 6. Error bars represent standard deviations.

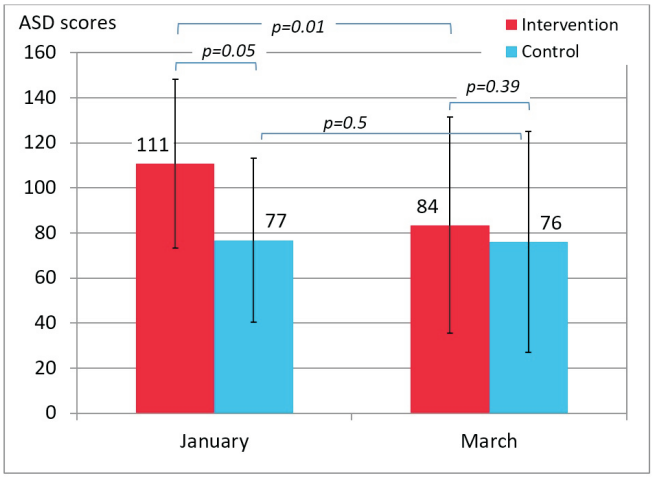


Fig. 4. Total Autism Spectrum Disorder Assessment Scale (ASD) scores at the beginning and end of the study. Data from the ASD questionnaire. Higher scores indicate greater severity. Intervention group n = 10, control group n = 6. Error bars represent standard deviations.

Short Sensory Profile (SSP). During the study, sensory sensitivity indicators in the intervention group improved by 13% (p = 0.02), while the control group showed a slight decrease (3%) (data not shown). There were non-significant differences of the SSP score between the groups in two time points. At the end of the study there was no significant difference between the groups (p = 0.25), which could indicate that the intervention group had more severe sensory problems at the beginning of the study.

Parent Global Impressions (PGI-2). There was a statistically significant difference between the groups in PGI-2 in mid-February (p = 0.03) compared to the baseline (zero change) at the beginning of January. Overall PGI-2 evaluation within three months showed 43% improvement in the intervention group (PGI-2 score was 1.2 compared to baseline or zero at the beginning of the study), and 14% (PGI-2 score 0.4) in the control group (p = 0.02). The largest improvements observed were more positive moods of the children, better attention, reduction of digestive symptoms, better language perception and understanding, and fewer temper tantrum episodes (Fig. 6).

Summary of the most prominent changes in autistic symptoms of children for both study groups is shown in Figure 7. For visualisation of reversed scales (ATEC, ASD, and ABC), they were plotted with improvement in the same direction as SSP and PGI-2 (Fig. 7). Overall, the intervention group showed 13–43% improvement during the study period (three months), while the control group showed 1–13% improvement in all performed measures (Fig. 7).

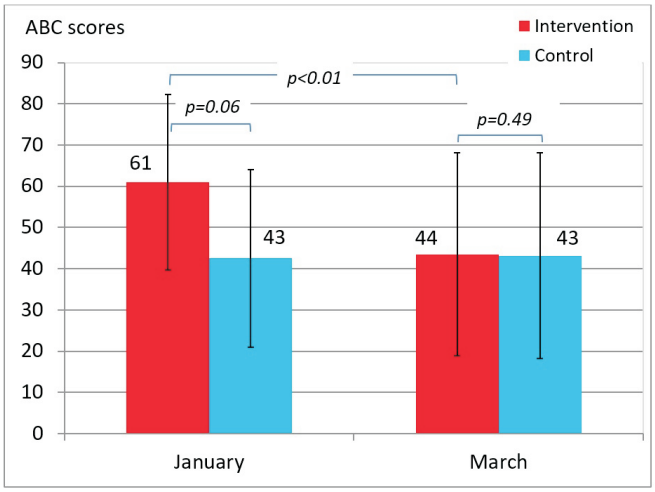


Fig. 5. Total Aberrant Behaviour Checklist (ABC) scores at the beginning and end of the study. Data from the ABC questionnaire. Higher scores indicate greater severity. Intervention group n = 10, control group n = 6. Error bars represent standard deviations.

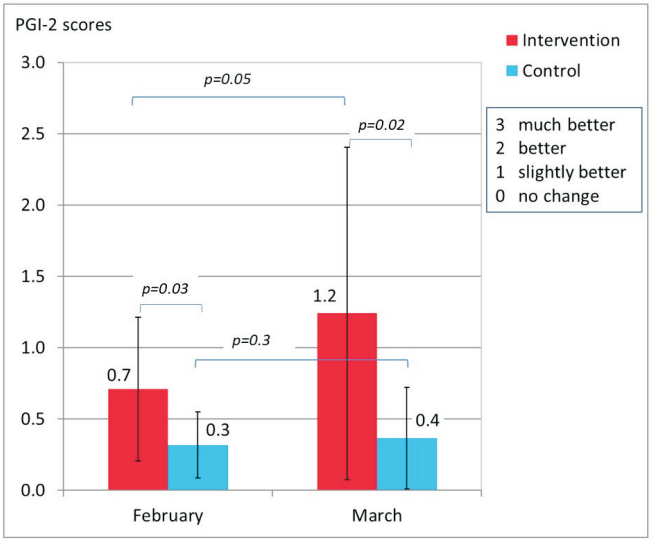


Fig. 6. Parent Global Impression – Revised-2 (PGI-2) scores at the beginning and end of the study. Data from the PGI-2 questionnaire. Intervention group n = 10, control group n = 6. Error bars represent standard deviations.

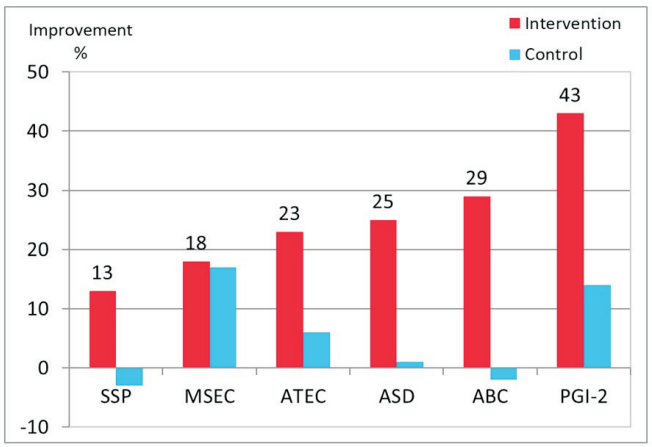


Fig. 7. Summary of significant changes in the evaluations of autistic symptoms of children. Data from the following questionnaires: Short Sensory Profile (SSP), Mental Synthesis Evaluation Checklist (MSEC, data not shown in this paper), Autism Treatment Evaluation Checklist (ATEC), Autistic Spectrum Disorder Assessment Scale (ASD), Aberrant Behaviour Checklist (ABC), and Parent Global Impression – Revised-2 (PGI-2). For SSP and PGI-2, an increase is an improvement; for other scales (ATEC, ASD, ABC), decrease of the score shows improvement. For comparison, in this graph scales ATEC, ASD, and ABC are normalised to the opposite improvement value. Intervention group n = 10, control group n = 6.

DISCUSSION

In this study, we observed overall improvement for all seven study measures for children with ASD that followed a SCD/GAPS dietary plan enriched with dietary supplements, compared to those that followed their regular diet.

The dominating view in the medical literature is that currently there is no single treatment for autism. However, studies have shown that dietary intervention and selected vitamins and minerals can significantly reduce symptoms of ASD (Lange *et al.*, 2015; Adams *et al.*, 2018).

The SCD/GAPS guidelines recommend removing sugar, grains, starchy vegetables, unfermented dairy products, and processed foods from the diet (Campbell-McBride, 2004). Instead, nutritionally rich foods should be included in the diet, with foods preferably cooked at home. In the study, parents reported 40–80% compliance with the SCD/GAPS diet, which can signify a relatively high ability for parents to follow the guidelines of SCD/GAPS. Moreover, the positive results obtained in this study and discussed further were also obtained for children whose parents reported only partial compliance with the SCD/GAPS diet. This confirms the potential of the SCD/GAPS diet to improve the condition of children with ASD, and therefore would allow for even larger improvements with higher compliance to the diet.

No randomisation of children was possible between the groups as families should be voluntarily ready to implement new dietary principles; it is not possible to enforce dietary changes and, even less so, guarantee 100% adherence to the diet. Because of the lack of randomisation, children in the intervention group displayed higher symptoms (worse scales) that those in the control group in some questionnaires that were used in this study. Larger improvement of ASD and GIT symptoms of these children, despite worse scales observed in the beginning of the study, can additionally prove the benefits of the SCD/GAPS diet.

Nutritional and metabolic differences in children with ASD compared to neurotypical children have been previously reported by Adams *et al.* (2011b). According to this large study, vitamin/mineral supplementation is beneficial in improving the nutritional and metabolic status of children with ASD, and in reducing their symptoms (Adams *et al.*, 2011b). Several large and relatively recent review articles (Gogou and Kolios, 2017; Li *et al.*, 2017) gave an overview of the vitamins and supplements most used to reduce ASD symptoms. For example, essential fatty acids are crucial for brain development. However, children with ASD usually have low omega-3 fatty acid levels in the body. In the current study, children were advised to take ω-3 fatty acids, vitamin D, probiotics, vitamin C and ascorbyl- palmitate (fat soluble vitamin C). Although five supplements were used in our study, blood tests were not planned during the study as it could be distressing for children with ASD (with the exclusion of voluntary vitamin D blood tests). Therefore, no isolated effect of supplements on the condition of child could be separated and measured. However, we can assume that part of the positive changes that we observed in this study might be related to the use of selected dietary supplements and vitamins.

As in the studies by Adams *et al.* (2011c; 2018), gastrointestinal symptoms of children in this study were assessed with a modified six-item GI Severity Index (6-GSI) questionnaire. The results of the study confirmed the facts that has been described in the literature (Buie *et al.*, 2010; Wasilewska and Klukowski, 2015; Rose *et al.*, 2017); children with ASD have often been reported to have gastrointestinal issues that are more frequent and more severe compared to children from the general population (Adams *et al.,* 2011c).

Almost all children enrolled in this study had some GIT issues — constipation, bloating, unformed stool, and abdominal pain. Unexpectedly, during the three-month period of the study, gastrointestinal symptoms decreased in both study groups, so it was not possible to draw conclusions about the effects of the SCD/GAPS diet and supplements on gastrointestinal health. The most marked difference was between January and February. Faecal odour, flatulence, and abdominal pain were most significantly reduced. Reasons for reduction of GIT symptoms in both groups may be explained by the following possibilities:

– during the study, parents in both groups were following their children's GIT symptoms more closely;

– teenagers were involved in this study (up to 18 years old), who may be not very eager to report details of their bowel movement to their parents;

– in some cases, parents had difficulties in evaluating the frequency and consistency of child's bowel movements.

As all the other questionnaires used in the study for neurological symptom evaluation showed a clear difference between the study groups, we assumed that this was due to the dietary and nutritional impact, and the positive effect could not be present without improvement of GIT function (although it was not clearly demonstrated by the 6-GSI questionnaire).

The SCD/GAPS diet and supplements used in the current study resulted in reduction of the ATEC score by 23% for the intervention group versus 6% for the control group. Similarly, the dietary (GF/CF/SF diet, excluding gluten, casein, soy) and nutritional approach used in a similar but larger study over a period of one year (Adams *et al*., 2018) reported significantly greater improvements on the total ATEC score for the treatment group compared to the non-treatment group (reduction by 28% vs. reduction by 6%). The ATEC questionnaire demonstrated that in just three months, the SCD/GAPS diet and supplements used in this study helped children to socialise better and to improve their behaviour and health.

The ATEC score already differed between the intervention group and control groups at the beginning of the study. This may be due to the fact that in the intervention group there were children with more severe ASD expression, and families of these children were more ready to make a change in their lives in order to improve their child's health.

The ASD Scale for the intervention group (score reduction by 25%) confirmed the results of the ATEC with a very similar result (23% for the ATEC score). The results of the ASD questionnaire in the control group demonstrated improvements in children's behaviour, language (improved speech perception and understanding) and social interaction, which were also observed in the ATEC questionnaire.

The ABC questionnaire analysed children's behaviour changes with the dietary and nutritional intervention, and demonstrated a marked improvement of behaviour by 29%, particularly regarding the reduction of irritability and hyperactivity in the intervention group. Again, this result is very close to the ABC results published in the paper by Adams *et al.* (2018) on dietary (GF/CF/SF diet) and nutrition intervention, where a 26% reduction in behavioural symptoms was reported for the treatment group.

SSP score improvement by 13% demonstrated the reduction of the overall sensory sensitivity in the intervention group — at the end of the study, children were more aware of their own bodies, had fewer sporadic movements, and were less sensitive to light and noise when compared to the baseline. A previous study (Adams *et al.,* 2018) reported a 12% increase in the SSP score for a treatment group, which was very close to the SSP result in the current study.

In the PGI-2 questionnaire, many positive aspects (positive mood, better attention, better language perception and understanding) were reported for the intervention group together with reduction of digestive symptoms. The PGI-2 questionnaire showed 43% improvement for the children at the end of the study compared to baseline. Overall, the PGI-2 score was almost the same (1.2) as the PGI-2 score reported in another study (Adams *et al.,* 2018) (1.24); this further confirms a very good correlation of the results of our study with data found in the literature.

To conclude, the overall results of the current study are in many aspects comparable to a similar study by Adams *et al.* (2018) in which the positive results with dietary and nutritional intervention for autistic children and adults were demonstrated.

Individual improvements for children in our study included speech and reading improvement, reduction of abdominal symptoms, better sleep, socialising, self-harm reduction, and a better appetite (child tried several new foods during the study). Only one child had an aggression episode during the study and required medication. All these changes for children of the intervention group would not have been possible without improved GIT functions of children during the study due to the specific carbohydrate diet (SCD/GAPS) and supplements. This study therefore confirms a gut-brain connection and the importance of gut health in children with ASD.

LIMITATIONS OF THE STUDY

Some limitations of the study involve the following aspects. First, as the treatment consisted of both diet and supplement intervention, it is not possible to determine the individual effect of each one of them on the resulting condition of the child. We did not perform blood tests to provide proper insight on the effect of dietary supplements and/or vitamins. Second, implementation of a healthy SCD/GAPS diet does not allow blinding of participants, and thus the results of the study could be partly affected by the placebo effect of parents in the intervention group. The analysis of the results

was based on self-assessment of symptoms by parents, and thus could contribute to the additional limitation of human error or bias in this study.

Third, the sample size of 17 children with ASD was too small to be able to generalise the findings. Not all the children were diagnosed by a physician; part of them were waiting to be diagnosed for ASD. The uneven distribution of diagnosed children between the groups is another limitation of the study. Differences between opinions of parents with children that already had a proved ASD diagnosis and those that did not, were not assessed in this study because of the small sample size. However, there is the possibility of information bias as the study was not blinded in regard to the diet and intake of supplements.

Fourth, the duration of this interventional study was rather short, but one must acknowledge that the implementation of a new dietary regimen in the family — a specific carbohydrate diet for a period of three months — is significant daily work for the parents, especially with an autistic child often being a picky eater. Therefore, we conclude that three months was a sufficient time period to observe the effects of the SCD/GAPS diet together with the supplements used in the study.

STRENGTHS OF THE STUDY

To the best of our knowledge, this pilot study of SCD/GAPS dietary intervention for ASD is the first of its kind. This is the first study where a SCD/GAPS diet was used for the treatment of gastrointestinal and some characteristic symptoms of autistic spectrum disorder in children. We proved our hypothesis showing that by reducing GIT symptoms for autistic children it was possible to reduce some symptoms of ASD. Good compliance of parents with the SCD/GAPS diet and supplementation, and their excellent compliance in completing questionnaires was another strength of this study. Although a small sample size was used and the duration of the study was short, its results were comparable to larger and more long-term studies involving nutritional support for one year and dietary intervention for three months.

CONCLUSIONS

The study confirmed that a SCD/GAPS diet, complemented with vitamins/dietary supplements, can improve behaviour, reduce hyperactivity and sensory sensitivity, and improve speech perception/understanding and socialisation of children with ASD. An SCD/GAPS diet and the use of recommended vitamins/supplements can be a safe and effective approach to help reduce some symptoms in children with ASD. As this was an exploratory study, larger studies over a longer time period would be necessary to confirm these results.

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SPECIFISKO OGĻHIDRĀTU DIĒTA (*SCD/GAPS*) UN UZTURA BAGĀTINĀTĀJI BĒRNIEM AR AUTISKĀ SPEKTRA TRAUCĒJUMIEM

Pētījuma mērķis bija izpētīt specifisko ogļhidrātu diētas un uztura bagātinātāju potenciālu dažu autiskā spektra traucējumiem (AST) raksturīgo simptomu mazināšanā bērniem. Darbs tika veikts kā prospektīvs gadījuma kontroles uztura intervences pilotpētījums, kas ilga trīs mēnešus. Pētījuma dalībnieki bija 17 bērni no Latvijas un Lielbritānijas ar AST diagnozi un bērni ar AST simptomiem, kas vēl gaida uz diagnosticēšanu (intervences grupa n = 10, kontroles grupa n = 7). Bērnu vecums bija no diviem līdz 18 gadiem. Intervences grupa saņēma uztura plānu — Specifisko ogļhidrātu diētu (*Specific Carbohydrate Diet, SCD*) un gremošanas sistēmas un psihisko traucējumu sindroma (*Gut and Psychology Syndrome, GAPS)* diētu — un dažus izvēlētus uztura bagātinātājus (neaizstājamās omega-3 taukskābes, askorbilpalmitātu, probiotikas, D vitamīnu, C vitamīnu). Simptomus bērniem pētījuma sākumā, vidū un beigās novērtēja viņu vecāki, izmantojot septiņas starptautiski validētas anketas, pētījuma laikā tika veikta arī šo anketu validācija latviešu valodā. Ģimenes uztura vadlīnijas ievēroja par 40–80%. Kuņģa-zarnu trakta simptomi mazinājās abās grupās, īpaši sāpes vēderā un vēdera uzpūšanās. Pētījuma beigās kopējais ATEC (Autism Treatment Evaluation Checklist) rādītājs intervences grupā samazinājās par 23%, vislielākais uzlabojums bija socializēšanās un veselības/uzvedības aspektos. Intervences grupā *Aberrant Behavior Checklist* (*ABC*) rādītājs samazinājās par 29%, vislielākais uzlabojums bija uzbudināmības un hiperaktivitātes apakškategorijās. Vispārējais vecāku globālais novērtējums (*Parent Global Impressions – Revised-2, PGI-2*) intervences grupā uzrādīja uzlabošanos par 43% salīdzinājumā ar 14% kontroles grupā, $p = 0{,}02$. Specifisko ogļhidrātu diēta *SCD/GAPS* un izmantotie uztura bagātinātāji ir droša un efektīva pieeja dažu AST simptomu mazināšanai bērniem.