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Iron Status in Young Children with Autism Spectrum Disorder

A thesis presented in partial fulfilment of the requirements for the
degree of

Masters in Science
in
Nutrition and Dietetics

at Massey University, Albany,
New Zealand.

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2015

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Abstract

Background: Autism Spectrum Disorder (ASD) is diagnosed when a child shows unusual social behaviour, difficulty communicating both verbally and non-verbally, and performing repetitive tasks. Children with ASD often present with unusual feeding patterns and behaviours, and overseas research shows children with ASD are at greater risk of iron deficiency and iron deficiency anaemia. Maintaining adequate iron levels is very important, as during periods of growth and development iron has a role to play in both brain structure and function. Therefore it is important for children to eat foods rich in iron or foods that optimise iron bioavailability. In New Zealand, the prevalence of iron deficiency in children is relatively low, being 1.6%. However, there is no published data on iron status or dietary factors associated with iron status in New Zealand children with ASD.

Objective: To investigate factors influencing iron status in a cohort of children with Autism Spectrum Disorder living in New Zealand.

Methods: Sixty nine children with ASD between the ages of 2.5-8 years took part in this cross-sectional study. Participants were required to complete an estimated four-day food diary, a dietary questionnaire, and a Behavioural Paediatrics Feeding Assessment Scale (BPFAS) questionnaire. Serum ferritin, serum iron, total iron binding capacity, transferrin saturation and haemoglobin were measured to determine iron status. Statistical analysis was performed using independent t-tests, Mann-Whitney, Chi-square and Fishers' exact test.

Results: Iron depletion was present in 32.9% of the sample population (serum ferritin ≤ 20 $\mu\text{g/L}$), and iron deficiency was present in an additional 4.3% (serum ferritin ≤ 12 $\mu\text{g/L}$). No participants had iron deficiency anaemia (serum ferritin SF ≤ 12 $\mu\text{g/L}$ plus Hb ≤ 110 g/L in 1-5 years; or Hb ≤ 115 g/L in 5-8 years). Participants in the iron replete group had significantly higher dietary protein intake ($P = 0.003$) and vitamin A intake ($P = 0.036$) compared to iron insufficient participants. The iron insufficient group had a significantly higher BPFAS frequency score than the iron replete group ($P = 0.022$), and significantly more participants in the iron insufficient group had a BPFAS score ≥ 84 ($P = 0.020$), indicating more feeding issues. No differences in patterns or factors affecting dietary intake were seen when comparing iron insufficient and iron replete groups.

Conclusion: Children with ASD in New Zealand appear to be at an increased risk of iron depletion and iron deficiency compared to neuro typical developing children. While no differences in dietary iron intake were seen between the iron replete and iron insufficient groups, iron replete participants had significantly higher intake of protein and vitamin A. More feeding behavioural problems were

identified in the iron insufficient group compared to the iron replete group. Further studies with a larger sample size should be undertaken to investigate other factors (dietary and non-dietary) to establish determinants of iron status in this population.

Acknowledgements

I would like to acknowledge a number of people who made this research possible. Firstly I would like to thank the participants and their families, for their time and effort dedicated to this study. The research would not have been able to be carried out without them. I would also like to thank my academic supervisory team. Dr Pam von Hurst for her guidance and support throughout this project as well as her knowledge. Dr Kathryn Beck for her support and extensive knowledge about iron and dietary assessment methods, as well as providing additional supervision at the end of this thesis. Dr Martin Dickens for his input, feedback and support throughout the thesis. I am grateful for each and every one of you, for your time and effort into providing feedback and making this project happen.

I would also like to thank Owen Mugridge, the research manager, who did a lot behind the scenes to ensure the project was completed in an efficient and timely manner. Also for Harjar Mazahery, the PhD candidate on the VIDOMA trial for her time in checking the food dairies and dietary questionnaires as well as collecting the anthropometric data. I would also like to thank Aimee Waring, another MSc student doing the thesis 'Dietary intakes, use of exclusion diets and supplements in children aged 2.5-8 years with ASD in New Zealand,' for her help in entering the food dairies into Foodworks as well as providing extra encouragement and support throughout the thesis process.

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List of Abbreviations

| | |
|------------------|---|
| ABA | Applied Behaviour Analysis |
| AI | Adequate Intake |
| AVB | Applied Verbal Behaviour |
| ASD | Autism Spectrum Disorder |
| BPFAS | Behavioural Paediatrics Feeding Assessment Scale |
| CD4 | Cluster of Differentiation 4 cells |
| CD8 | Cluster of Differentiation 8 cells |
| CHO | Carbohydrate |
| CI | Confidence Interval |
| CRP | C-reactive Protein |
| Dcytb | Duodenal Cytochrome B Reductase |
| DF | Dietary Fibre |
| DHB | District Health Board |
| DMT1 | Divalent Metal Ion Transporter 1 |
| DNA | Deoxyribonucleic Acid |
| DSM-5 | Diagnostic and Statistical Manual of Mental Disorders, fifth edition |
| DSM-4 | Diagnostic and Statistical Manual of Mental Disorders, fourth edition |
| DTT | Discrete Trial Training |
| DVD | Digital Versatile Disc |
| EAR | Estimated Average Requirement |
| FAO | Food and Agriculture Organisation of the United States |
| Fe | Iron |
| Fe ²⁺ | Ferrous iron |
| Fe ³⁺ | Ferric iron |
| FFQ | Food Frequency Questionnaire |
| FPN1 | Ferroportin-1 |
| GFCF | Gluten-Free Casein-Free Diet |
| GP | General Practitioner |
| Hb | Haemoglobin |

| | |
|---------|--|
| HCP1 | Haem Carrier Protein 1 |
| HDEC | Health and Disabilities Ethics Committee |
| Hct | Haematocrit |
| Hep | Hepcidin |
| ID | Iron Deficiency |
| IDA | Iron Deficiency Anaemia |
| MCV | Mean Cell Volume |
| MFP | Meat Fish Poultry Factor |
| MSc | Masters in Science |
| NDNS | National Diet and Nutrition Survey (UK) |
| NHI | National Health Number |
| NRV | Nutrient Reference Values |
| NZ | New Zealand |
| NZEO | New Zealand European |
| PDD | Pervasive Developmental Disorder |
| PDD-NOS | Pervasive Developmental Disorders – Not Otherwise Specified |
| PRT | Pivotal Response Training |
| RBC | Red Blood Cell |
| RCT | Randomised Controlled Trial |
| RDI | Recommended Daily Intake |
| RNA | Ribonucleic Acid |
| SD | Standard Deviation |
| SF | Serum Ferritin |
| SFA | Saturated Fatty Acids |
| sTfR | Soluble Transferrin Receptor |
| sTfR:SF | Transferrin Receptor to Serum Ferritin Ratio |
| TEACCH | Treatment and Education of Autistic and Related Communication-Handicapped Children |
| TIBC | Total Iron Binding Capacity |
| TS | Transferrin Saturation |
| UL | Upper Level of Intake |

| | |
|--------|------------------------------------|
| UK | United Kingdom |
| USA | United States of America |
| VIDOMA | Vitamin D, Omega-3 in Autism Study |
| WDHB | Waitemata District Health Board |
| WHO | World Health Organisation |
| ZPP | Zinc Protoporphyrin |