Exercising opportunities to prevent chronic disease: The CAPO Kids trial

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Exercising opportunities to prevent chronic disease: The CAPO Kids trial
Abstract

Physical activity is considered to be an effective strategy to improve children’s health and reduce the risk of developing chronic diseases; osteoporosis and obesity being two examples with particularly high morbidity and increased mortality. An exercise program to improve both bone and reduce fat would be ideal. Problematically, bone is known to respond primarily to brief bouts of high-impact activity, while the traditional exercise recommendation to reduce fat is longer duration, low to moderate intensity aerobic activity.

The overall aim of the current work was to develop a novel exercise program for pre and peripubertal children to improve bone and minimise the accumulation of fat.

The thesis describes four studies, presented as two published manuscripts, one in press and another under review. In the first study, we conducted a comprehensive systematic review, to determine the effects of previous bone-targeted exercise interventions on bone, muscle and fat in school-age children. Meta-analyses were conducted to quantify the findings of the sixteen studies included in the review. We concluded that improvements in fat have previously been observed as secondary benefits of bone-targeted in-school exercise programs.

The subsequent study, described in papers two and three, examined the CAPO Kids exercise program, which was specifically designed to improve indices of musculoskeletal, cardiovascular and metabolic health, and physical performance of pre and peripubertal boys and girls. The program was a nine-month, cluster randomised controlled exercise intervention, incorporated into the school schedule of Year 5 and 6 students three times per week, for ten minutes per session. Activities comprised high-intensity jumping and capoeira,
a Brazilian sport that combines martial arts with dance. A range of health outcomes were examined before and after the 9-month program. We found that the CAPO Kids program improved parameters of bone and metabolic health including heel bone quality, waist circumference, estimated maximal oxygen consumption and resting heart rate.

The final study was an observational examination of the metabolic and mechanical loads associated with the CAPO Kids activities. We determined energy expenditure during the 10-minute CAPO Kids session, and ground reaction forces of eleven CAPO Kids manoeuvres, in a sub-group of participants. We confirmed that the CAPO Kids program generates metabolic and mechanical loads of a magnitude that are typically recommended to promote healthy adaptations in fat and bone.

Overall, the current thesis demonstrates the potential for simultaneous benefits of the CAPO Kids program to both musculoskeletal and metabolic systems of pre and peripubertal children. Furthermore, CAPO Kids was a simple, appealing and feasible program, able to be implemented during school time, without disrupting the normal academic schedule. Based on those findings, we conclude that future translation of brief high intensity impact exercise programs into the broader school system holds promise for paediatric health and chronic disease prevention.
STATEMENT OF ORIGINAL AUTHORSHIP

This is to certify that the work contained in this thesis has not been previously submitted for a degree or diploma at any other higher education institutions. This thesis contains no material previously published or submitted for publication by another person except where due reference has been made. Due acknowledgement has been made in the text for all other material used.

Signed: Rossana Candiota Nogueira

Date: 01 September 2014
ACKNOWLEDGMENTS

This dissertation would not have been possible without the contributions from, and support of, many people along the way. I would like to take the opportunity to recognize the following mentors, colleagues, friends and family for their efforts on my behalf.

I would first like to express my appreciation to my supervisors, Associate Professor Belinda Beck and Doctor Benjamin Weeks, for their tireless efforts and constant encouragement throughout my PhD journey; I could not have wished for better supervisors. Belinda has been my role model since day one. I thank her for her patience during all my long conversations, her understanding during millions of knocks on her door, and her assistance in helping me understanding her sayings. I am truly grateful for her belief in me and particularly appreciate her directions, her systematic ways of doing things (including thinking), and her efforts to teach me how to do the same. Through her kindness and professionalism, her expertise and sympathy, she not only guided me throughout the course of this PhD, but also taught me lessons for life. She is not only an astonishing supervisor; she has changed the course of my life. Ben is also an outstanding supervisor, as he was keenly involved in all elements of this work and is a great example of a wonderful and professional teacher. His constructive feedback and critical (and very detailed) comments were crucial for the development of this work. He sat by my side for hours and hours during the last three and a half years, to help me learn things I never thought I was capable of including detailed statistical analysis and writing a well-structured paragraph (using humorous examples). I am truly grateful for every minute he has dedicated to me and mentorship was fundamental for the successful completion of this work.
I would like to express my gratitude to the School of Allied Sciences and to the Centre for Musculoskeletal Research at Griffith University for their assistance and financial support, providing me with a tuition fee and a living stipend scholarship. In addition, I would like to thank the Australian and New Zealand Bone and Mineral Society (ANZBMS) and the American Society of Bone and Mineral Research (ASBMR) for their financial contribution. This generous assistance gave me the opportunity to develop this project and present my research at prestigious conferences around the world.

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During the course of this doctorate, I met many people who became part of my Australian family, and no matter where we all are or end up, we know how important we are to each
other. In particular, I wish to thank Luciane, Aderson and Lucca; I will never forget all you have done for me.

I am truly indebted to my family and friends for their belief in this endeavor. I am blessed for having such a supportive and caring family back home in Brazil, who have always provided me with all the support I needed; even when I decided to move to the other side of the world. I specially thank my parents Flavia Candiota and Augusto Nogueira for their unconditional love and encouragement, both of you are my role models for life.

My final acknowledgement is devoted to a very special person, who truly believed we could live on the other side of the planet because, if we are together, it does not matter where we are. My boyfriend, husband, soul-mate and best friend Maiquel was brave enough to take this adventure with me, and I am forever grateful for everything he has done to allow me to accomplish my dream. I will never forget how much he gave up by believing in me and living this dream by my side. I love him with all my heart.
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KEYWORDS

Bone; Bone geometry; Bone loading; Bone mass; Bone mineral content; Bone mineral density; Children; Chronic diseases; Energy expenditure; Exercise; Fat; Ground reaction forces; Lean mass; Maturity; Musculoskeletal system; Osteoporosis; Overweight; Obesity; Paediatrics; Peak height velocity; Physical activity; Puberty.
# ABBREVIATIONS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tr>
<td>ANOVA</td>
<td>Analysis of variance</td>
</tr>
<tr>
<td>ANZBMS</td>
<td>Australian and New Zealand Bone and Mineral Society</td>
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<tr>
<td>APHV</td>
<td>Age of peak height velocity</td>
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<tr>
<td>ARPANSA</td>
<td>Australian Radiation Protection and Nuclear Safety Agency</td>
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<tr>
<td>BMC</td>
<td>Bone mineral content</td>
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<td>BMD</td>
<td>Bone mineral density</td>
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<td>BMI</td>
<td>Body mass index</td>
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<tr>
<td>BPAQ</td>
<td>Bone-specific Physical Activity Questionnaire</td>
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<td>BUA</td>
<td>Broadband ultrasound attenuation</td>
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<tr>
<td>BW</td>
<td>Body weight</td>
</tr>
<tr>
<td>cBPAQ</td>
<td>Current Bone-specific Physical Activity Questionnaire</td>
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<tr>
<td>CSA</td>
<td>Cross-sectional area</td>
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<tr>
<td>CSMI</td>
<td>Cross-sectional moment of inertia</td>
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<td>CT</td>
<td>Computed tomography</td>
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<tr>
<td>CVD</td>
<td>Cardiovascular disease</td>
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<td>DXA</td>
<td>Dual-energy x-ray absorptiometry</td>
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<td>EE</td>
<td>Energy expenditure</td>
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<tr>
<td>FFQ</td>
<td>Food frequency questionnaire</td>
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<tr>
<td>FN</td>
<td>Femoral neck</td>
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<tr>
<td>GRF</td>
<td>Ground reaction forces</td>
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<tr>
<td>LS</td>
<td>Lumbar spine</td>
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<tr>
<td>MRI</td>
<td>Magnetic resonance imaging</td>
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<tr>
<td>NCD</td>
<td>Non-communicable diseases</td>
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<tr>
<td>pBPAQ</td>
<td>Past Bone-specific Physical Activity Questionnaire</td>
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<tr>
<td>PE</td>
<td>Physical education</td>
</tr>
<tr>
<td>PES</td>
<td>Physiotherapy and Exercise Science</td>
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<tr>
<td>Acronym</td>
<td>Full Form</td>
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<tr>
<td>PF</td>
<td>Proximal femur</td>
</tr>
<tr>
<td>PHV</td>
<td>Peak height velocity</td>
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<tr>
<td>pQCT</td>
<td>Peripheral quantitative computed tomography</td>
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<tr>
<td>QCT</td>
<td>Quantitative computed tomography</td>
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<tr>
<td>QUS</td>
<td>Quantitative ultrasonometry</td>
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<tr>
<td>SI</td>
<td>Stiffness index</td>
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<td>SOS</td>
<td>Speed of sound</td>
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<tr>
<td>SPSS</td>
<td>Statistical Package for the Social Sciences™</td>
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<tr>
<td>TR</td>
<td>Greater trochanter</td>
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<tr>
<td>vGRF</td>
<td>Vertical ground reaction forces</td>
</tr>
<tr>
<td>VO₂ max</td>
<td>Maximal oxygen consumption</td>
</tr>
<tr>
<td>WB</td>
<td>Whole body</td>
</tr>
<tr>
<td>WHO</td>
<td>World Health Organisation</td>
</tr>
<tr>
<td>YAPHV</td>
<td>Years from age of peak height velocity</td>
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THESIS ORGANISATION

- **Chapter 1** presents a general introduction of the complete work and a brief overview of its background and aims.

- **Chapter 2** presents a review of the scientific literature pertinent to the premises, methodology and execution of the project. It begins with chronic diseases and introduces childhood overweight and obesity as well as osteoporosis and its significance as a global health issue. It elaborates on the bone response to mechanical loads, in particular, the effect of physical activity. Measurement devices are addressed.

- **Chapter 3** details the methods of each study. First, it summarises the systematic review and meta-analyses processes. Then, the process of recruitment and procedures employed to implement the CAPO Kids intervention are described. Finally, data collection and analysis procedures adopted to characterise energy expenditure and ground reaction forces associated with CAPO Kids activities are presented. Descriptions of the statistical analyses of each study are included.

- **Chapters 4, 5, 6 and 7** comprise the individual scientific papers published or submitted to peer-reviewed journals. Each paper is a self-contained paper own introduction, methods, results and discussion sections. However, all references are presented together at the end of the thesis.

- **Chapter 8** provides a discussion of the overall findings of the work as a whole, summarising and synthesising the results and their significance. Recommendations for future research directions are also included.

- **The Appendices** contain copies of all supporting documents utilised in the project including the informed consent package, questionnaires and the case report form.
PUBLICATIONS AND CONFERENCE PRESENTATIONS

Manuscripts in print


Manuscripts accepted for publication


Manuscripts under review

Other publications arising during candidature


Oral presentations


**Poster presentations**


