Developing a simple tool for screening the health and motor performance-related fitness of children.

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Associate Supervisor: Professor, Dr Roger Hughes
ABSTRACT

The health and fitness of Australian children, including the onset of overweight and obesity, largely as a result of increasing sedentary behaviour, decreasing physical activity and poor dietary intake, can and will impact on Australia’s future health, education, economic and social prosperity. It is therefore important to enhance opportunities for Australia’s children to be physically active and as fit and as healthy as possible. Although much attention has been given to healthy eating and increasing physical activity in order to maintain or improve the health and wellbeing of Australian children, little attention has been given to motor proficiency as a determinant of physical activity in children. It is proposed that in order to curtail the current levels of child overweight and obesity, children must develop adequate motor proficiency and cardiorespiratory fitness, as these two attributes will likely enhance a child’s ability to participate in age-appropriate physical activity. It is therefore essential to develop systems and tools that will identify early, those children who have poor health-related fitness with motor incompetency as a possible contributing factor. This thesis aimed to develop a simple tool for accurately screening the health and motor performance-related fitness of children to guide the referral process to physiotherapy for early intervention of motor incompetency. In doing so, the KidFit Screening Tool was developed using a number of methodological approaches, over three (3) stages.

The initial stage included a ‘needs assessment’ that started with understanding the literature around the impact of childhood overweight and obesity in Australian and global contexts, as well as determining the current and potential role of physiotherapists in preventing and dealing with this chronic condition. The review of the literature (Chapter 2) suggests that physiotherapists are skilled to deal with motor incompetence (a factor associated with overweight and obesity) but despite this, the national survey of Australian physiotherapists (Chapter 3) demonstrated little engagement by Physiotherapists with overweight or obese children for a number of
reasons that were predominantly related to individual workplace service models and policy (e.g. ‘...not prioritized by service’). The tools and outcome measures being used by physiotherapists were specifically investigated as part of this survey to help inform the development of the screening tool. Notably, less than half of Physiotherapists surveyed, assessed the motor skills of overweight and obese children and this was also attributed to the environment and service models where physiotherapists worked. This survey data provided insight into the reasons why physiotherapists were providing only limited services to overweight and obese children and these factors require consideration regarding the utility of the KidFit Screening Tool.

The second stage of this doctoral research involved the development of a pilot screening tool, which was based on the available literature regarding the health and motor performance-related fitness impairments of overweight and obese children. This pilot screening tool, along with a number of additional previously validated health and motor proficiency measures were used during data collection with a total of 260 children aged 5 to 17 years. The series of studies undertaken in this second stage of the doctoral research, explored the relationship between motor proficiency and health-related fitness measures and examined the psychometric properties of the newly designed measures within the KidFit Screening Tool. Prior to data collection a quality assurance step was undertaken to ensure that all persons collecting data (Physiotherapists and PE Teachers) were appropriately trained in taking each of the measures and the inter-tester reliability was assessed for each of the newly designed measures (Chapter 4). The absolute agreement between testers was very high (CA > 0.9) for each of the measures supporting the notion that adequately trained PE teachers and physiotherapists were appropriate to assist with data collection for this research and could potentially assist with screening the health and motor performance-related fitness of children on a larger scale. Chapter 5 examined the relationship between children’s motor proficiency and health-related fitness to further inform the development of the KidFit Screening Tool. Significant predictive relationships ($r^2>0.6$, $p<0.01$) were revealed between motor proficiency and BMI, waist
circumference and VO₂peak. These results indicate that motor proficiency should be a focus of investigation for children with poor health-related fitness. In Chapter 6 the concurrent and predictive validity of the Modified Shuttle Test-Paeds (MSTP) was investigated. A significant and strong correlation was found between VO₂peak and the MSTP (r²=0.749, p<0.001) suggesting it is a valid measure of cardiorespiratory fitness with a high predictive validity for estimating VO₂peak in children. The MSTP was therefore included in the refined KidFit Screening Tool as a health-related fitness measure. In Chapter 7 the test-retest reliability and the concurrent validity of the Speed and Agility Motor Screen (SAMS) as a motor performance-related fitness measure for children was investigated. The SAMS had strong test-retest reliability (ICC=0.87) and strong predictive validity for determining gross-motor ability with overweight/obese children (r²=0.641, p=0.001). Based on these psychometric properties, the SAMS was also included in the refined KidFit Screening Tool for feasibility testing.

The final stage of this doctoral research involved a modest feasibility study (n=57) to test the diagnostic accuracy of the KidFit Screening Tool for identifying children with and without health and motor performance-related fitness impairments (Chapter 8). The KidFit Screening Tool, uses designated cut-off values for the two measures included (i.e. the SAMS and the MSTP) and ROC analysis revealed moderate to high accuracy for identifying children with and without: overweight/obesity (AUC: 0.895); poor motor skills (AUC: 0.822) and poor cardiovascular fitness (AUC: 0.912). These results address the main aim of this PhD research program, providing an accurate screening tool that can be used by those who work with children to guide decisions regarding referral to specialised services for detailed investigation of motor proficiency as an underlying contributor to a child’s poor health-related fitness. Future studies beyond this doctoral research are planned to develop normative data for the KidFit Screening Tool and to test its generalisability and utility to a wider population of Australian children and adolescents.
DECLARATION BY AUTHOR

This thesis is submitted to Bond University in fulfilment of the requirements of the degree of Doctor of Philosophy. This thesis represents my own original work towards this research degree and contains no material which has been previously submitted for a degree or diploma at this University or any other institution, except where due acknowledgement is made.

I have clearly stated the contribution of others to my thesis as a whole, including statistical assistance, survey design, data analysis, significant technical procedures, professional editorial advice, and any other original work used or reported in my thesis. The content of my thesis is the result of work I have carried out since the commencement of my research higher degree candidature and does not include material which to a substantial extent has been submitted for the award of any other degree or diploma of a university of institution of higher learning.

Nikki R Milne
PhD Candidate

Date: 18th December, 2014.
DECLARATION OF CONTRIBUTIONS TO CO-AUTHORED WORKS CONTAINED IN THE THESIS

All co-authors on the chapters/papers indicated below have approved these papers for inclusion in Nikki Milne’s doctoral thesis.


*Declaration:* Milne was responsible for the design of the study, data collection, data analysis, writing, editing and submitting the abstract and poster. Low Choy (previous PhD supervisor) supervised the design and data collection for the study. Low Choy and Steele (Faculty statistician at the time) guided the analysis of data and reviewed the progressive drafts of the abstract and poster prior to presentation.


*Declaration:* Milne was responsible for the design of the study, data collection, data analysis, writing, editing, and submitting the article. Low Choy (previous PhD supervisor) supervised the design and data collection for the study. Low Choy, Leong, Hughes and Hing guided the analysis of data, reviewed the progressive drafts of the paper and provided detailed feedback.


*Declaration:* Milne was responsible for the design of the study, data collection, data analysis, writing, editing, and submitting the article. Leong and Hing supervised the
design of the study, guided the data collection and analysis, reviewed the progressive drafts of the paper and provided detailed feedback. Professor Nancy Low Choy (previous PhD supervisor) supervised the initial study design and Dr Michael Simmonds (Accredited Exercise Physiologist), assisted with the technical components of measuring peak oxygen uptake with participants.

Milne N, Simmonds MJ, Hing W. (2014). Modified Shuttle Test-Paeds: a valid cardiorespiratory fitness measure for children. Declaration: Milne was responsible for the design of the study, data collection, data analysis, writing, editing, and submitting the article. Simmonds and Hing supervised the design of the study, guided the data collection and analysis, reviewed the progressive drafts of the paper and provided detailed feedback. Associate Professor Elaine Beller and Dr Robin Orr provided advice regarding the statistical analysis of data.

Milne N, Hing W. (2015). Validating the Speed and Agility Motor Screen (SAMS) as a motor performance-related fitness measure for children. Journal of Australian Strength and Conditioning. Full paper submitted. Declaration: Milne was responsible for the design of the study, data collection, data analysis, writing, editing, and submitting the article. Hing supervised the design of the study, guided the data collection and analysis, reviewed the progressive drafts of the paper and provided detailed feedback. Associate Professor Elaine Beller, Dr Robin Orr and Dr Allan Abbott provided advice regarding the statistical analysis of data.
STATEMENT OF CONTRIBUTIONS BY OTHERS TO THE THESIS AS A WHOLE

Professor Nancy Low Choy (previous PhD supervisor) assisted in the original development of the research objectives, formulation of the research methodology and interpretation of the data for the survey of physiotherapists regarding child obesity practices.

Professor Roger Hughes, Associate Professor Gary Leong and Professor Wayne Hing (current PhD supervisors) have assisted with formulation of research methodology and interpretation of the data for subsequent studies within this research higher degree. These supervisors have also provided thesis guidance through review of the manuscript, editorial assistance and detailed comments and feedback.

Dr Michael Simmonds, assisted with supervising the design of one of the studies in this thesis document, assisted with the data collection and analysis of peak oxygen uptake for children in this study as an Accredited Exercise Physiologist and reviewed the progressive drafts of the manuscript for the related study, through to journal submission.

I as the PhD candidate developed the objectives, wrote the ethics applications, recruited the participants, conducted the research studies, conducted and interpreted the statistical analysis and wrote and edited the thesis following feedback from supervisors.
PUBLICATIONS AND CONFERENCE PRESENTATIONS

a) Publications

Abstracts:


Papers:


**b) Conference presentations by the candidate directly related to this Thesis**

**Poster Presentations:**


**Podium Presentations (presenting author underlined):**


   NOTE: Awarded Best Podium Presentation, Paediatric Stream.
ADDITIONAL PUBLICATION BY THE AUTHOR RELEVANT TO THE THESIS
BUT NOT FORMING PART OF IT

a) Publications

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There are many people to whom I owe a great deal of gratitude for helping me realise the completion of this PhD and I would like to take this opportunity to thank them.

Firstly to my supervisors. I owe an enormous amount of gratitude to my primary supervisor, Professor Wayne Hing. Wayne, like me has two young children at home, and whilst maintaining just the right amount of pressure to keep me on the PhD pathway, he has always reminded me about my main priority during these last few years….my family. It is never easy, juggling the guilt that one feels whilst continually trying to squeeze in PhD work between school pick-ups, bath time and bed time……not to mention the late night stints to try and stay on track with PhD activities while your family are sleeping. Wayne has been amazingly flexible with the support he has offered me, taking lots of weekend and late night calls to answer questions and help me solve problems related to my PhD studies. He was also instrumental in allowing me to take time away from work earlier this year to kick off my PhD write-up period. At one point I felt like I had no friends as he had cautioned them from making contact with me, to prevent any distractions with my usual departmental duties. He even threatened to take my key off me, so I could not come in to work! I would like to thank Wayne for his guidance and friendship during this process; it has been an amazing learning journey. Thank you also to Professor Nancy Low Choy for encouraging me to dive in head first when I initially started this PhD and for not letting me run in the other direction. Professor Roger Hughes and Associate Professor Gary Leong have also been instrumental in developing my research skills. Although Roger has been extremely busy and hard to access at times he has taught me a number of things relevant to becoming a good researcher. Roger has taught me to write through the lens of the reader. With each piece of work I have submitted to Roger, he has challenged me with a great deal of red pen (much of which is hard to read!) asking me to answer questions that I had not thought about previously. Although testing at times,
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Thanks also to my friends, colleagues and peers for helping out when I needed more hands than I had, to complete data collection. Thank you to Kate McDougall, Rebecca Harrington and Lisa Gillespie for your help with data collection in the early days of my PhD. Rebecca and Lisa (both primary school teachers) were integral to helping me develop systems for data collection in school environments. They taught me how to best communicate with teachers and parents to maximise the participation rates for my studies. Rebecca also gave me plenty of driving tips on our expeditions out west to collect data!!

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When I started this journey, my children were only 1 and 3 years old (what was I thinking?). With both my husband and I working full time, this meant that we needed the help of our parents to assist with many days of baby-sitting duties, particularly before our children started school. My Mum (Rhonda) and Dad (Royce) have been very supportive of me throughout my life, and especially with my education. I respect them enormously and I know they are responsible for installing in me a strong work ethic and a determined attitude which has been critical for completing this PhD. I would also like to thank my Mother in law (Carole) and Father in law (Ernie) for always being there to help us out when we were struggling to fit everything in. They always found a way to make it down to help with baby-sitting the kids when deadlines were looming. I am sure they have fielded a few frustrated outbursts that my husband has expressed when I celebrated finishing one study and launched straight into the next. I am sad to say that during the time I have been undertaking my PhD, my Nanna ‘Meryl’ and Grandfather ‘Pa’ have passed away. Both my Nanna and Pa were very relaxed people (at least in their later years) and at times when I was stressed about my PhD work, I found myself channelling their wise words and calming nature to stop myself having a meltdown. My Pa was extremely proud that I was completing my PhD and
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This brings me to the people who I owe the most gratitude to. This thesis is dedicated to my own family; my gorgeous husband Kyle, and my amazing children, Nyalli and Diesel. Nyalli and Diesel provided me with the best motivation. They have been so patient whilst Mum wrote her ‘PhD book’. I have two things in my office that have kept me going this year. One is a photo of Diesel smiling at me with a grin from ear to ear that always lifted my spirits when I looked at it. The second is a ‘To Do’ list that my daughter Nyalli wrote. Her ‘To Do’ list says: “To love Mum, to have a girls day, go have girls lunch, come home, to watch a movie together, massage each other’s feet, go for a ride on scooters, hugs!, kisses!, have a spectacular dinner, go to bed with a warm bed, remember to smile and have a great day with Mum”. As the last few days of thesis preparation are now here, I find myself with a grin from ear to ear, as I will finally be able to fulfil Nyalli’s ‘To Do’ list with my family and make a regular thing of it! Lastly, but definitely not the least, I owe a great debt to my husband, Kyle. Without him, I would never have been able to undertake this PhD. He is the BEST Dad and the BEST husband in the entire world and I am so lucky to share my life with him. Kyle has kept our children happy and safe, endured my roller-coaster of moods (excited, frustrated, deflated and elated) and kept me sane, with all the support I could possibly have asked for. Without your love, support and motivation, Kyle, this PhD would not have been possible. Now you can buy a Harley!
KEYWORDS

Paediatric, Obesity, Overweight, Cardiorespiratory, Motor Proficiency, Fitness, Health, Children, Adolescents, Screening, Physiotherapy.

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AUTHOR’S CONFIRMATORY STATEMENTS

The opinions expressed in this study are those of the author and do not necessarily reflect those of Bond University.

The National Statement of Ethical Conduct in Human Research (developed jointly by the National Health and Medical Research Council, Australian Research Council and the Australian Vice Chancellors Committee, March 2007) has been adhered to during the conduct of this research.
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<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>ABS</td>
<td>Australian Bureau of Statistics</td>
</tr>
<tr>
<td>AIHW</td>
<td>Australian Institute of Health and Welfare</td>
</tr>
<tr>
<td>ANOVA</td>
<td>Analysis of Variance statistic, for analysing between group means</td>
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<tr>
<td>AUC</td>
<td>Area Under the Curve (related to ROC Analysis)</td>
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<tr>
<td>APA</td>
<td>Australian Physiotherapy Association</td>
</tr>
<tr>
<td>APA NPG</td>
<td>Australian Physiotherapy Association, National Paediatric Group</td>
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<tr>
<td>BEEP Test</td>
<td>Australian version of the 20m Modified Shuttle Run Test</td>
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<tr>
<td>BMI</td>
<td>Body Mass Index</td>
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<tr>
<td>BMI Z</td>
<td>Body Mass Index (standard deviation from BMI for age)</td>
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<tr>
<td>BOTMP</td>
<td>Bruininks Oseretsky Test of Motor Proficiency</td>
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<tr>
<td>BOT2</td>
<td>Bruininks Oseretsky Test of Motor Proficiency (2&lt;sup&gt;nd&lt;/sup&gt; Edition)</td>
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<tr>
<td>BP</td>
<td>Blood Pressure</td>
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<td>BUHREC</td>
<td>Bond University Human Research Ethics Committee</td>
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<tr>
<td>CA</td>
<td>Cronbach’s Alpha statistic</td>
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<tr>
<td>CDC</td>
<td>Centres for Disease Control and Prevention</td>
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<tr>
<td>CI</td>
<td>Confidence Interval</td>
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<tr>
<td>Concurrent Validity</td>
<td>a statistical method to assist with defending the use of a test for predicting another outcome. Concurrent validity can be demonstrated when the test being examined, correlates highly with another measure that has previously been validated.</td>
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<tr>
<td>CRF</td>
<td>Cardiorespiratory Fitness</td>
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<td>CV</td>
<td>Cardiovascular</td>
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<tr>
<td>CVD</td>
<td>Cardiovascular Disease</td>
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<tr>
<td>DCD</td>
<td>Developmental Coordination Disorder</td>
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<tr>
<td>Diagnostic Accuracy</td>
<td>a statistical method used to examine how well a measure discriminates between having and not having a condition.</td>
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<tr>
<td>DF</td>
<td>Degrees of Freedom</td>
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**DXA** – Dual Energy X-ray Absorptiometry

**ECG** - Electrocardiogram

**ER** – Efficiency Ratio

**FFM** – Fat Free Mass

**FM** – False Negative

**FP** – False Positive

**GAS** – Goal Attainment Scale

**Go4Fun** – NSW modified MEND Program  
[go4fun@betterhealthcompany.org](mailto:go4fun@betterhealthcompany.org)

**GP** – General Practitioner

**HDL** – High density lipoprotein

**Health-related Fitness** - Cardiorespiratory endurance, muscular strength and endurance, body composition and flexibility

**HPE teacher** – Health and Physical Education teacher

**HR** – Heart Rate

**HTWR** – Height Weight Ratio

**HW** – hypertriglyeridemic waist

**ICC** – Intra-class Correlation Coefficient statistic

**IMT** – Intima-media thickness

**Inter-tester Reliability** – the degree of agreement between testers

**IOTF** – International Obesity Task Force

**KidFit Screening Tool** – A screening measure of exercise capacity made up of the MSTP and the SAMS

**LDL** – Low density lipoprotein

**LR+** - Positive likelihood ratios

**LR-** - Negative likelihood ratios

**MD Team** – Multidisciplinary team

**MEND** – Mind, Exercise, Nutrition….Do it!  
[http://au.mendcentral.org](http://au.mendcentral.org)

**MMT** – Maastricht’s Motor Test

**MMT** – Milne Motor Test (NOTE: The name of this test was changed to SAMS during the write up phase of this thesis).
**MSTP** – Modified Shuttle Test Paeds

**NCDS** – National Chronic Disease Strategy

**NHMRC** – National Health and Medical Research Council

**NPG** – National Paediatric Group (of the APA)

**NSMDA** – Neuro Sensory Motor Developmental Assessment

**NSW** – New South Wales

**NVP** – Negative Predictive Value

**OT** – Occupational Therapist

**PA** – Physical Activity

**PACER** – Progressive Aerobic Cardiovascular Endurance Run

**PDAY** – Pathobiological Determinants of Atherosclerosis in Youth Study


**Performance-related Fitness** - Balance, coordination, speed, agility and power, which all reflect the performance aspect of physical fitness

**PE teacher** – Physical Education teacher

**Paediatric Physiotherapist** – A physiotherapist who is specifically trained or experienced at working with children and families.

**PPV** – Positive Predictive Value

**Predictive Validity** – a statistical method used to assess the extent to which the result of a measure/test can predict the score or result on a criterion measure.

**PT** - Physiotherapist

**QLD** - Queensland

**QOL** – Quality of Life

**RERpeak** – peak respiratory exchange ratio

**ROC Analysis** – Analysis of the Receiver Operating Characteristic or ROC Curve. The ROC curve is analysed by plotting the true positive rate against the false positive rate at various threshold settings.

**RSDP** – Resting Diastolic Blood Pressure

**RSBP** – Resting Systolic Blood Pressure

**SAMS** – Speed and Agility Motor Screen
SCFE – Slipped Capital Femoral Epiphysis
SD – Standard Deviation
SE – Standard Error
SES – Socioeconomic status
SLS – Single leg stance
SLSEC – Single Leg Stance Eyes Closed
SLSEO – Single Leg Stance Eyes Open
SPSS – Statistical Package for the Social Sciences
SS – Standard Score (related to the BOT2)
T2DM – Type 2 diabetes mellitus

**Test-retest Reliability** – the consistency or variability in repeated measurements taken by a single person using the same instrument.

TP – True Positives
TPS – Total Point Score (relating to subtests within the BOT2)
TN – True Negative
ULFT – Upper Limb Flexibility Test
US – United States of America
VO₂ – Oxygen Consumption
VO₂ max – Maximal Oxygen Consumption
VO₂ peak – Peak Oxygen Consumption
VT – Ventilatory Threshold
VT₁ – First Ventilatory Threshold: a marker of intensity where lactate begins to accumulate in the blood.
VT₂ – Second Ventilatory Threshold: a marker of intensity where the lactate has quickly accumulated in the blood, where the person needs to breath heavily to compensate. Also known as the lactate threshold
WC – Waist Circumference
WC-IC – Waist Circumference measured at the iliac crest
WC-U – Waist Circumference measured at the umbilicus
WCPT – World Confederation for Physical Therapy
WHO – World Health Organisation

WHTR – Waist circumference to height ratio

20m MSRT – 20 metre Modified Shuttle Run Test