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Anthropometric measurements in Canadian children: A scoping review

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Abstract

Objective

The objective of the current study was identifying what forms of anthropometric measurement are currently being utilized with Canadian children and youth and what are the gaps in the literature on this topic.

Method

The current study utilized a scoping review methodology in order to achieve the study objectives. Online databases Medline and PubMed and CINAHLwere used to search articles from the last decade (2002-2012) that addressed Canadian children aged 2 years-18 years.

Synthesis

50 studies were included in this review. A variety of anthropometric measurements were identified including body mass index, waist circumference, hip-to-waist ratio among others. Six of the included studies (12%) utilized nationally representative data from large scale studies. BMI was the most reported form of measurement with 88% of studies colleting it. Waist circumference was a distant second with 20% of studies reporting it. Several gaps in the literature exist, with regards to First Nations (FN) research, many of the measurement methods were not used. Additionally FN accounted for only 2.5% of the study's sample. The majority of studies took place in Quebec (29%) and Ontario (27%).

Conclusion

Body mass index is the most reported method of anthropometric measurement used for children. Efforts should be taken by health care practitioners and researchers to collect other forms of measurement in order to assist in understanding the validity of other measures and their value when used with children. Furthermore, attention needs to be put into utilizing and studying various forms of anthropometric measurement across all Canadian regions and populations.

Introduction

The use of anthropometric measurements (comparative measurement of the human body) is a well established practice for many clinical purposes including screening and health risk assessment.[1] This is particularly useful in the paediatric population as these measurements can be used to track growth rate and identify abnormal growth trends.[2] The most commonly utilized of these measurements is Body Mass Index (BMI) which is calculated using the height and weight of the individual (Kg/M^2).[3] Both the Canadian Paediatric Society and the Dietitians of Canada recommend the screening of BMI for children above the age of 2.[2]

Canada is a diverse country with a variety of unique settings from rural to urban to northern/Arctic. Healthcare is delivered at provincial and territorial level and each region is composed of unique environments and populations; therefore it is important to have representation from all regions when considering the health of the nation.[4] In a recent report, Dr. Kellie Leitch acknowledged that Canadian children and youth, while fortunate in many ways, are poorly ranked among key indicators of health including obesity, when compared to other developed countries.[4] Of 21 of the world's wealthiest countries, Canada only ranks 12^{th} in regards to child well-being.[5] More recently an update on this report has placed Canada at 17^{th} out of the 29 wealthiest countries in regards to child well-being and a horrific 27^{th} in regards to health.[6] This poor ranking highlights the need for Canadians to focus on child health and closely monitor our progress. This begins by understanding the forms of measurement being used and

investigating methods to improve the screening and monitoring of child health. Canadian children have a unique health profile and need to be investigated independently from other children.[4] In the case of weight based concerns such as obesity, there are clear regional differences across the country.[7-9]

The current trend of increasing BMI in children has generated a great deal of attention due to its links with a variety of negative health outcomes such as cardiovascular disease and diabetes.[10-11] Some provinces have developed strategies and mandates to address the obesity problem; Ontario for example recently released a report focusing on childhood obesity in the province, and included a variety of recommendations to reach their ambitious target of reducing childhood obesity by 20% in 5 years.[12] Therefore, with the growing attention placed on childhood obesity,[13] anthropometrics, specifically BMI, have become of great importance. [14-15] Canadian guidelines recommend using World Health Organization's growth charts as reference,[2] which consider a child between 2 and 19 years of age who has a BMI below 3rd percentile as underweight, a BMI below the 85th percentile as normal weight, 85-97th centile as overweight or >97th centile as obese.[16] These categories are used as a proxy for body fat which is associated with varying health risks.[17-18] It is however important to note that there are 'healthy' children with BMI calculations that identify them as unhealthy.[3, 14, 19-20] For example, varying growth rates could lead to a child having a higher weight than their peers but not an advanced amount of body fat which would warrant the 'unhealthy' label.[3,14] Likewise, there are individuals whose BMI falls in the 'healthy' range, who are at greater risk for poor health outcomes due to factors such as poor nutrition, sedentary behaviors and negative environmental influences. A heavy focus on BMI can cause some

individuals to be misclassified and thus fail to be provided with the most appropriate advice.[21-22] BMI classification serves to excaudate between group differences (normal weight vs overweight) and severely downplays the potential individual differences within each group making the assumption that all within the group are homogenous.[22] The current practice of using population level data (BMI classification) in a clinical setting is problematic as it oversimplifies the screening and care of the patient.[22] this highlights the need to explore the options of supplementing BMI data in detail. British children have their BMI measured through the Child Measurement Programme despite the warning from the National Screening Committee. The committee suggested that the BMI measurement not go ahead in children as they were not convinced that they were doing more good than harm.[23] Nicholls points out that BMI classification in isolation is simplistic and does not represent the health of a child well.[22] He also states that a heavy focus on BMI classification can promote the unintended harm of increased weight bias and discrimination which is of great concern to children.[22]

Regular anthropometric tracking in children is a valuable tool in prevention, diagnosis and treatment of many conditions, including excess fat mass.[21] A rich set of growth trend data provides health care practitioners with valuable information about abnormal rates and sudden fluctuations in growth which could highlight items for a health care practitioner to explore in more detail.[14] However, caution should be taken to not exaggerate the importance on any singular measurement, as there are always limitations.[24] The value of BMI when used at an individual level or in a special population (children with disabilities, for example) has been questioned as it provides minimal information about the health of that individual patient and fails to identify causes

of weight-based concerns such as diabetes or cardiovascular disease.[3, 21-23] For example, one study suggested that the use of BMI in children could underestimate the importance and effect of socioeconomic factors such as parental education and poverty.[25] BMI itself is designed as a means of simplification of data for the purpose of studying population trends. As such, the misuse of BMI creates the risk of over-simplifying a very complex issue that is obesity.[22] Obesity is a health condition that has many interacting contributors and the full complexity of the issue is not yet known. Current systems of anthropometric measurement and classification do not provide an accurate reflection of the severity of weight-based health.[3] Some even suggest that a heavy focus on BMI can be detrimental to the patient through the adoption of risky weight loss methods, eating disorders and weight bias.[19-20, 22, 26]

A new screening tool for children could potentially utilize a combination of anthropometric measurements as well as assessments of health behaviors and history in order to provide the health care practitioner with a well-rounded and individualized picture of the health needs of an individual child. While BMI is certainly the most popular and most reported form of anthropometric measurement, there is a variety of different measurements that can potentially be utilized in conjunction or separately from BMI. The development of such a tool begins with the identification of the current forms of anthropometric measurement available and the gaps in the literature surrounding them.. The results of this review will inform future research into the development of a novel health screening tool for Canadian children, The Healthy Body Scorecard.

Research question

The current study utilizes scoping review methodology, as scoping reviews are designed to examine the extent and range of research available in an identified research area, and to identify gaps in the literature.[27-28] Although they have been criticized for not being as rigorous as systematic reviews,[29] they are, in fact, a distinct entity and can be conducted with differing levels of detail, ranging from a brief count of the number of articles on a topic to a more comprehensive mapping of the available literature and findings.[30-31] The scoping review approach utilized in the current study was one that identified current research, highlighted methods of anthropometric measurement used for Canadian children and identified gaps in the literature. The research questions were: 1) What anthropometric measures are being utilized with Canadian children and how prevalent are these measures published research? And, 2) What gaps in the literature exist?

Methodology

Search strategies

Infants under the age of 2 years are involved in a rapid and irregular state of growth and therefore make it very difficult accurately categorize them in standardized growth charts.[2, 12, 21] Growth measurement of Canadian children between the age of 2 years and18 years has been highlighted as an important part of the primary health care.[2] Therefore, studies included in this review included Canadian children between 2 years and18 years years.

The online databases Medline and PubMed and CINAHL were used to search English language journal articles from the last decade (2002-2012) in order to focus on

current literature. A set of keywords and subject headings were used for the initial search including: Anthropometry, anthropometric measurement, body height, weight, body mass index, growth and growth curve combined with the terms children/child and Canada. The reference lists of identified articles were also screened for additional resources. A secondary search was conducted once key topic areas were identified including: Waist circumference, leg length to height ratio, waist to hip ratio, waist to height ratio, skin fold thickness, girth, body composition, obesity, and adipose tissue again all combined with the terms children/child and Canada. Only studies that utilized objectively measured anthropometric methodologies were included.

Results

The initial search identified 605 items to be screened. Review of abstracts reduced the number of articles to be retrieved to 87. Application of the inclusion and exclusion criteria to full text articles resulted in 50 studies being included in the current review (Table 1). Studies ranged from nationally representative data to small sub-population studies and included a variety of age ranges that fell within this review's 2 years -18 year old threshold.

Anthropometric measurement

The studies used a variety of different measurements (Table 1). Body Mass Index calculation was by far the most collected form of anthropometric measurement with 88% (n=44) of studies utilizing the method. Over half of the studies (n=28) examined BMI alone. Waist circumference (WC) was the next most popular form of measurement with

20% (n=10) of studies collecting WC measurements. Blood pressure and body fat percentage (measured using bio-electric impedance or sum of 5 skinfolds) were utilized by 10% (n=4) and 12% (n=5) of studies respectively. Another two studies observed waist to height ratio.[34-35] Waist-to-hip ratio and skinfold calipers (sum of 5 skin folds) had a single study represent the measurement methods.[34,36] Another single study utilized leg length and sitting height measurements for the purpose of assessing physical maturity.[37]

Population characteristics

While six studies reported measurement of nationally representative data from large scale studies, the remaining inclusions in this review were spread across varying sub-populations. For example eight (16%) of the included studies were targeted specifically at Inuit or First Nations populations. Of the 50 studies included in this review, four (8%) directly targeted Caucasian-only populations. Many of the studies focused on small and very specific sub-populations such as congenital heart disease patients,[38] or hockey players[39] One of the larger studies included in the review (which had a sample of 6392) specifically targeted the first generation (child and parents born outside of Canada) immigrant and second generation (child born inside Canada with at least one parent born outside Canada) immigrant population.[40]

Sample size

The 50 included studies in the current review represent a total sample size of 67051 Canadian children. The six studies that are from nationally representative samples account for 47% of the total sample population for the review. The single study that addressed the immigrant population represented 9.5% of the overall sample size. The

nine studies focused on First Nations populations that were incorporated into the review represented 2.5% of the total sample size.

Each of the identified forms of anthropometric measurement represented different percentages of the total sample population for the review (Table 2). For example, BMI measurement was collected in 94% of the sample population. The second most popular form of measurement was waist circumference, which was reported for 13% of the sample. Waist to height ratio was measured in 3% of the sample. The remaining forms of measurement reported each represented 2% or less of the total sample population of the review.

Discussion

The research using anthropometric measurement in Canadian children is heavily skewed towards the collection of BMI measurements. This is not surprising due to the simplicity of the measurement and analysis of BMI- of all possible anthropometric measurements, the height and weight collection used in the BMI calculation is likely to be the least invasive of all and requires the least amount of expertise to acquire accurate results.[3] Furthermore, it should be noted that BMI measurement is the recommended clinical measurement for this age group.[2] This is evident in the research as 28 of the 50 studies solely examined BMI. However, simplicity does not always equate to the best choice, as BMI does have limitations.[3,15,21] While BMI has been shown to be useful in identifying population trends and disease risk, the use of height and weight measurements on the individual level do not provide sufficient information on which to base medical screening alone.[3,15] For example, BMI fails to account for many important variables

such as lean tissue mass, fat distribution, and health behaviours that are linked to poor health outcomes.[3, 14, 19-20]

The inclusion of a wide variety of anthropometric measurements aside from BMI shows that there are other simple and useful data collection methods that can be utilized in conjunction with BMI to provide a rich data set. Waist circumference has gained popularity across all populations as it provides insight into distribution of adipose tissue in the body.[41-43] This can be particularly useful in the Aboriginal population as they have been shown to be affected differently than other Canadians by adiposity.[36, 44-45] This review however, clearly identifies a gap in research using measurements such as waist circumference, hip-to-waist ratio and leg-length-to-height ratio. These types of measurements provide information of mass distribution and growth trends that are potentially useful for health screening and should be explored in more detail. Therefore, future studies should be designed to collect other appropriate and simple measurements which will result in rich data sets. Growth data that goes beyond height and weight could allow health care practitioners and researchers to identify abnormal growth patterns as well as provide an opportunity to explore relationships between measures and health outcomes in greater detail. This may enable greater accuracy in identifying health issues and unhealthy behaviors, as well as highlight the issues that need greater attention in regards to children's growth and development.

While a good portion of this review is based on nationally representative data (50% of the entire sample) from large scale studies, there are still some important gaps in the review studies in regards to population representation. Particularly, First Nations populations are underrepresented with only 2.5% of the sample. First Nations represent a

unique and important population with health trends that differ considerably from the national norm.[47-50] Statistics also show them to have higher rates of obesity and related co-morbidities compared to the rest of the country, which could be for a number of reasons[46,48] The use of waist circumference measurement in this population may provide insight into the fat mass distribution and the severity of weight based health issues. Interestingly, four of the nine studies addressing the First Nations population included the measurement of waist circumference. This review however failed to identify any First Nations research that utilized other valuable forms of measurement such as leg-length-to-height ratio and hip-to-waist ratio. It would therefore be beneficial for future research in this population to address the gaps identified in this review for the purpose of better understanding of the usefulness of these measurements in this population.

Geographically, the review identified some key characteristics. The majority of the studies took place in Ontario and Quebec. This is likely due to the large population base in these provinces as well as the number of large research centers and universities in these two populations. While all regions of the country are accounted for by the 6 nationally representative studies, the remaining studies included in the review identified some areas that lack attention in the literature. Specifically Manitoba populations had not been represented individually outside of the nationally representative data. Furthermore, other regions such as British Columbia and the Maritimes are underrepresented. It would be valuable to be able to compare all of the various forms of anthropometric measurement across the different regions to nationally representative data, which would be particularly valuable when developing cross-Canada guidelines.

Limitations

For feasibility reasons, all of the searches and study inclusion decisions were performed by a single researcher. Systematic review methodology requires study inclusion decisions to be conducted by two separate investigators, to ensure that only evidence meeting strict criteria is considered.[46] However, scoping reviews take a more inclusive approach, aiming to include all information that has relevance to a specific topic.[23-24]. Therefore, single reviewer studies have been successfully completed in scoping reviews where the inclusion and exclusion criteria are not complex.[47]

Only published studies were included in this review, a noted limitation of many types of literature reviews.[23]

Conclusion

The purpose of this review was to identify the forms of anthropometric measurement currently in use for the Canadian child and youth population. The variety of measurements identified in this review reflect the range of measures available for studying the growth trends of Canadian children. The secondary purpose of this review was to identify any gaps in the literature in regards to the measurements, geographic location and sample population. All of the identified forms of anthropometric measurement aside from BMI would benefit from greater attention in future research. In order to strengthen the findings of future research, researchers should take the opportunity to collect other simple anthropometric measurements such as waist circumference, hip circumference and leg length. This would allow for a greater understanding of the reliability of these methods as well as growth trends in children and

the link to health outcomes. While a large portion of the sample was nationally representative, efforts should be made to utilize the anthropometric measurements in all regions in order to allow for regional comparisons. Furthermore, specific attention needs to be taken to collect anthropometric data from First Nations children as they were underrepresented in the studies included in this review.

Table 1: Review articles						
Author	**Year**	**Measures**	**Age Range**	**Sample Size**	**Location**	**Special population**
Hayek et al.	2012	Height, weight, BMI	2-5	296	Artic communities	First Nations
Melka et al	2012	Height, weight, BMI, blood pressure	12-18	598	Quebec	French Canadian
Shields et al.	2011	Height, weight, BMI	6-11	854	Canada	Nationally representative
Twells & Newhook	2011	Height, weight, BMI	0-5	1026	Newfoundland	
Maximova et al.	2011	Height, weight, BMI	9-12	6392	Quebec	Immigrants
Woodruff et al.	2010	Height, weight, BMI	10-12	405	Ontario	
Khalil et al.	2010	Height, weight, BMI, waist circumference, body fat % (BI)	9-18	125	Quebec	First Nations
Herman et al.	2009	Height, weight, BMI	7-18	374	Canada	
Downs et al.	2009	Height, weight, BMI	8-12	201	Quebec	First Nations
Dubois et al.	2007	Height, weight, BMI	3-5	1549	Quebec	
Spence et al.	2008	Height, weight, BMI	3-5	501	Alberta	
Dubois et al.	2007	Height, weight, weight for height	0-5	354	Quebec	
Sherar et al.	2007	Height, weight, sitting height	14-15	281	Saskatchewan	Hockey players
Galloway	2006	Height, weight, BMI	7-14	504	Ontario	Rural
Shields	2005	Height, weight, BMI	2-17	8661	Canada	Nationally representative
Thompson et al.	2005	Height, weight, BMI	7-17	1653	Nova Scotia	
Nakano et al	2005	Height, weight, BMI	10-12	216	Canadian artic/Yukon	First Nations
Stefan et al.	2005	Height, weight, BMI	2-14	110	Ontario	Congenital heart disease patients
Hay et al.	2004	Body fat % (BI)	8-14	206	Ontario	Caucasian
Smith et al.	2002	Height, weight, BMI	4-14	101	Ontario	First Nations

Hajna et al.	2012	BMI, waist-height ratio, waist-hip ratio, waist girth, hip girth,	9-13	1570	Ontario	
Danyliw et al.	2011	Height, weight, BMI	10-13	10038	Canada	Nationally representative
Kakinami et al.	2012	BMI, blood pressure	9-16	2466	Quebec	
Chaput et al.	2012	BMI, waist to height ratio	5-10	550	Quebec	Caucasian, obese parent
Tomlin et al.	2012	BMI, waist circumference,sum-of-5 skinfolds	9-13	148	British Columbia	First nations
Pausova et al.	2012	Body fat% (BI), blood pressure	12-18	499	Quebec	Caucasian
Liu et al.	2012	BMI, leg length to height ratio	9-14	1166	Ontario	
Panagiotopoulos et al.	2011	BMI, waist circumference	0-18	231	British Columbia	
Bilinski et al.	2011	Height, weight, BMI	8-13	99	Saskatchewan	Rural
Chaput et al.	2011	BMI, waist circumference	5-10	550	Quebec	
Larouche et al.	2011	BMI, waist circumference	8-12	315	Ontario	
Spence et al.	2012	Height, weight, BMI	4-5	1730	Alberta	
Johnston et al.	2011	Height, weight, BMI	9-11	305	Alberta	
Katzmarzyk et al.	2007	Height, weight, BMI	6-18	7081	Canada	Nationally representative
Katzmarzyk	2004	Waist circumference	11-18	3064	Canada	Nationally representative
Downs et al.	2008	Height, weight, BMI, waist circumference	9-12	178	Quebec	First nations
Syme et al.	2009	Height, weight, BMI, waist circumference, body fat % (BI)	12-18	425	Quebec	
Moffat et al.	2005	Height, weight, BMI	6-10	261	Ontario	3 varying communities
Anderson et al.	2010	Height, weight, BMI, waist circumference	8-16	416	Saskatchewan	First Nations
Paradis et al	2010	Height, weight, BMI, blood pressure	6-19	2079	Canada	Nationally

						representative
Mirwald et al.	2002	Height, weight, BMI, sitting height, leg length, leg length-to-sitting-height ratio	8-16	152	Saskatchewan	
Banach et al	2007	Height, weight, BMI	9 yrs	1497	Ontario	
Verret et al	2010	Height, weight, BMI	7-12	70	Quebec	Boys, Attention deficit and hyperactivity disorder
Stock et al	2007	Height, weight, BMI, heart rate	4-13	232	British Columbia	
St. John et al.	2008	Height, weight, BMI	7-17	2296	Nova Scotia	
Haque et al.	2006	Height, weight, BMI	6-17	801	Ontario	Northern Ontario
He et al.	2006	Height, weight, BMI	6-13	1570	Ontario	
Larouche et al	2011	Height, weight, BMI, waist circumference	8-12	315	Ontario	
Pabayo et al.	2010	Height, weight, BMI (Z-score)	4-8	1170	Quebec	
He et al.	2004	Height, weight, BMI	2-6	1370	Ontario	

Table 2 Percent representation of measurement methods (N=67051)		
Measurement	**N**	**Percentage of sample population**
BMI	63282	94%
Waist circumference	8592	13%
Body fat percentage	756	1%
Weight for height	354	0.50%
Sitting height	433	0.60%
Waist to height ratio	2120	3%
Hip to waist ratio	1570	2%
Hip girth	1570	2%
Skinfold	148	0.20%
Leg length to height ratio	1166	2%
Leg length to sitting height ratio	152	0.20%

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