



**Cardiovascular and metabolic risk factors in a healthy  
Norwegian child population: The Health Oriented  
Pedagogical Project (HOPP)**

- a cross-sectional study -

Master's thesis

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*Author:*

*Wei Hai Deng*

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**Masters of Public Health Nutrition, 2017-2019**

Department of Nursing and Health Promotion  
Faculty of Health Sciences  
Oslo Metropolitan University

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“Be anxiously concerned with the needs of the age ye live in,  
and center your deliberations on its exigencies and requirements.”

- Bahá'u'lláh

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Wei Hai Deng

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## List of abbreviations

%F	Percentage fat
BMI	Body mass index
CMD	Cardiometabolic diseases
CVD	Cardiovascular disease
DBP	Diastolic blood pressure
DDS	Dietary diversity score
FBG	Fasting blood glucose
FFQ	Food frequency questionnaire
GDPR	General Data Protection Regulation
HbA1c	Hemoglobin-A1c
HDL-C	High-density-lipoprotein cholesterol
HOMA-IR	Homeostatic model assesment for insulin resistance
HOPP	The Health Oriented Pedagogical Project
IDF	International Diabetes Federation
LDL-C	Low-density-lipoprotein cholesterol
mCRP	Micro C-reactive protein
MetS	Metabolic syndrome
MM	Muscle mass
PA	Physical activity
REK	Regional committees for Medical and Health Research Ethics
SBP	Systolic blood pressure
SES	Socioeconomic status
STROBE	Strengthening the reporting of observational studies in epidemiology
TC	Total serum cholesterol
TC/HDL-ratio	Total serum cholesterol to serum high-density-lipoprotein ratio
TG	Triglycerides
WC	Waist circumference
WHtR	Waist-to-height ratio

## Abstract

**Background:** Risk of developing cardiometabolic diseases (CMDs) can already be found in child populations. This risk is known to track from childhood into adulthood and in some cases concludes in cardiovascular or metabolic diseases. Studying the clustering of a number of known risk factors is likely a better predictor of future disease risk than single components. Increasing severity of multiple factors increases the probability of multiple comorbidities. Moreover, analyzing degree of clustering allows for stratified analyses and targeted preventive strategies. Nationally representative studies are necessary to monitor development of CMD risk among children. The primary aim of this thesis was to investigate the clustering of risk factors for cardiovascular and metabolic diseases in a large, healthy representative Norwegian child population.

**Methods:** Baseline (2015) data (n = 1056) from The Health Oriented Pedagogical Project (HOPP) was analyzed for clustering of CMD risk factors. A correlation analysis was used to select factors for the risk score. A CMD risk score was calculated by adding number of factors in the least desirable quartile. A relative risk ratio  $>1$  to an expected binomial probability distribution was defined as non-random clustering of risk factors.

**Results:** Following the correlation analysis, five of eleven components were included: waist circumference (WC), total serum cholesterol/serum high-density lipoprotein cholesterol-ratio (TC/HDL-ratio), systolic blood pressure (SBP), haemoglobin-A1c (HbA1c), and the Andersen fitness test. No significant clustering of risk factors was found for any of the 0-5 CMD risk scores despite a risk ratio of 5.8 (95% CI = 0.7-46.9) at five risk factors.

**Conclusions:** There was no clustering of risk factors among Norwegian children aged 6-12 years based on this sample. The present results using a continuous CMD risk score could regardless provide useful insights for future studies.

## 1. Background

A growing body of scientific evidence suggests that risk of developing cardiometabolic diseases (CMD) starts early, tracks from childhood into adulthood, and may resolve itself in cardiovascular diseases (CVD) and type-2 diabetes later in life (Bugge, El-Naaman, McMurray, Froberg, & Andersen, 2013; Jayawardene, Lohrmann, Dickinson, Talagala, & Torabi, 2017; Li et al., 2016; Petkeviciene et al., 2015; van Vliet et al., 2011). Obese children are not only at increased risk of being obese throughout their lives but also of becoming diabetic and of developing CVDs (Llewellyn, Simmonds, Owen, & Woolacott, 2016; Simmonds, Llewellyn, Owen, & Woolacott, 2016). Body mass index (BMI) is predictive of future atherosclerotic CVDs and high fasting insulin predictive of future prediabetes (Ajala, Mold, Boughton, Cooke, & Whyte, 2017). Measures like obesity and high BMI in childhood may therefore be predictors of CMDs in adulthood. It is however possible that these associations vary across life stages because of different hormone profiles and risk exposures.

The International Diabetes Federation (IDF) definition of the metabolic syndrome (MetS) is a dichotomous measure that covers a number of physiological factors; waist circumference (WC), triglycerides (TG), high-density lipoprotein cholesterol (HDL-C), blood pressure, and fasting plasma glucose (“IDF,” 2015). The measures are important causative risk factors to heart diseases, stroke and diabetes. A clustering of risk factors is therefore thought to be indicative of future metabolic diseases. The criteria are well established for clinical application but has a few notable limitations. For one, the definition is meant for adults. Considering habits are developed through a lifetime, those diagnosed with MetS are faced with the arduous task of changing well-established lifestyle habits. Cut-offs for anthropometry, hemodynamic measures, and physical fitness in children are moreover age-specific owing to differing physical developmental stages (Goodman, Daniels, Meigs, & Dolan, 2007). Dichotomization of risk factors could additionally mask the tracking of disease risk throughout stages of life, as it only uncovers diagnosed MetS, not “risk” as a spectrum *towards* diagnosed disease (Kelly et al., 2011).

Continuous cluster scores rather than single components are likely better predictors of future disease risk (Kelly et al., 2011; Stoner et al., 2017). The theory is that increasing severity and magnitude of each component increases the probability of multiple comorbidities (Lars Bo

Andersen et al., 2015). Using degree of clustering, number of risk factors, allows for analyses separated by severity of the risk. Dichotomous scores could as such hide real associations between lifestyle behaviors and CMDs. Tracking correlation of risk factors from adolescence into adulthood has also been found to increase in clustered scores compared to the dichotomous MetS definition (Anderson et al., 2016; Kelly et al., 2011). Using clustered risk scores enables better tracking of disease risk from child- to adult-populations and are important in identifying early intervention opportunities.

### **1.1. Theoretical foundation behind a cardiometabolic disease risk score**

There is no consensus definition on continuous CMD risk scores for children. Number of scientific publications on the topic have however increased in recent years, though researchers use a range of components for the score (Kamel et al., 2018). The lack of a harmonized definition makes comparison studies challenging. Nevertheless, single studies still provide important insights into key population characteristics in regards to cardiometabolic health.

Validity of a CMD risk score must follow a few basic principles. All included variables need to be known correlates of CVDs and metabolic diseases. Further, multicollinearity should be avoided to mitigate skewed weighing of single components. Lastly, continuous ratio variables must form the foundation of the score. There are many methods to creating constructs, such as K-means clustering analysis, hierarchical cluster analysis, or principal component analysis. A challenge these methods pose is that they introduce sample-specific weighing of individual factors. The final cluster score would represent different characteristics in each population, limiting clinical applicability and comparisons across populations (Kamel et al., 2018; Stoner et al., 2017). A simple correlation analysis of all available risk factors could be the most reproducible for future research.

The following subchapters cover risk factors to CMDs based on literature searches. The chapters follow often found categories in factor analyses (Anderson et al., 2016; Kamel et al., 2018; Stoner et al., 2017).

### *1.1.1. Adiposity*

Frequent measures of adiposity in regards to CMDs include WC, BMI, skinfold thickness, waist-to-height ratio (WHtR), and body fat percentage (%F) (Abarca-Gómez et al., 2017, 2017; Chung, Park, Park, & Yoo, 2016; T. J. Cole & Lobstein, 2012; Kamel et al., 2018). The common denominator is visceral fat. Visceral and subcutaneous fat is associated with increased release of free fatty acids and pro-inflammatory cytokines, leading to worsening insulin resistance and lower HDL-C levels.

WC, %F, and WHtR are likely better predictors of visceral fat than BMI. While BMI is commonly used for defining overweight or obese individuals (WHO, 2016), it cannot distinguish between low or high fat percentage or the proportion of muscle mass, nor does it reflect adipose tissue or the location of fatty tissue well (Anderson et al., 2016). %F is patently a more accurate measure of adipose tissue, though a disadvantage is the lack of information on where the fat is distributed. WC and WHtR does include measures of central adiposity.

A challenge with WC is that it requires age-, sex-, and race-specific cut-offs. This could complicate diagnostic settings withal require population-specific data to establish cut-off values. The fact that it does not consider height is also a limitation, as there is a possibility that shorter individuals have higher CMD risk than taller people with the same WC (Ashwell, Gunn, & Gibson, 2012; Chung et al., 2016). WHtR may be preferable in diagnostic settings since it does not require age-, sex-, and race-specific cut-points (Mehta, 2015). WC has however been found to be a slightly stronger predictor of CMDs than WHtR in children and adolescents (Chung et al., 2016; Mehta, 2015).

### *1.1.2. Blood lipids*

Measures of blood lipids that correlate with CMDs are TG, total cholesterol (TC), HDL-C, low-density-lipoprotein cholesterol (LDL-C), non-HDL-C, as well as various ratios between these (Kamel et al., 2018; Lemieux et al., 2001; Maumus, Marie, Siest, & Visvikis-Siest, 2005; Wadhera, Steen, Khan, Giugliano, & Foody, 2016). The majority of studies on clustering of CMDs include at least one lipid measure (Kamel et al., 2018). Poor lipid profiles are associated with being overweight and obese as well as higher CMD risk (Lemieux et al., 2001; Petkeviciene et al., 2015; “IDF,” 2015).

Due to limited opportunity for fasting, neither TG nor LDL-C was available for analysis in this paper. Both are commonly used markers for CVDs and metabolic health (Forouzanfar et al., 2016; Gakidou et al., 2017; Jacobson et al., 2015). The Friedewald equation of LDL-C includes TG and HDL-C and is therefore normally preferred as a more comprehensive measure in classifying lipid levels ( $\text{LDL-C (mg/dL)} = \text{TC} - \text{HDL-C} - \text{TG}/5$ ) (Jacobson et al., 2015; Martin et al., 2013).

The reporting of TC and HDL-C is also indicative of CVD risk however, where a ratio of TC/HDL-C is often used (Kamel et al., 2018). While a single component like TC gives an idea of the individual's lipid levels, it fails at providing a full profile of its constituents. A TC/HDL-ratio does on the other hand show proportion of “good” cholesterol.

### *1.1.3. Metabolic factors*

Important metabolic factors to CMDs include fasting blood glucose (FBG), fasting insulin, glycated hemoglobin-A1c (HbA1c) and the homeostatic model assessment for insulin resistance (HOMA-IR) (Abarca-Gómez et al., 2017; Brouwer, Stolk, Liem, Lemmink, & Corpeleijn, 2013; Steene-Johannessen, Kollé, Anderssen, & Andersen, 2009; “IDF,” 2015). While fasting glucose and insulin levels are associated with higher TG and lower HDL-C levels (Lemieux et al., 2001), HbA1c and HOMA-IR are likely more relevant for this thesis paper.

FBG is indicative of short-term glycemic control and HbA1c of chronic glycemic control (Stoner et al., 2017). This makes HbA1c a better measure for a child population where long-term effects of risk factors are concerned. HOMA-IR quantifies insulin sensitivity and  $\beta$ -cell function, and is therefore suitable for a continuous CMD risk score while also including those with impaired glucose tolerance (Wallace, Levy, & Matthews, 2004). Both HbA1c and HOMA-IR could be relevant in assessing CMD risk, though only HbA1c was available for analysis in this thesis paper.

### *1.1.4. Hemodynamic measures*

Relevant hemodynamic measures include systolic and diastolic blood pressure (SBP and DBP), resting heart rate, and mean arterial pressure (Bleich et al., 2017; Brouwer et al., 2013; Kamel et al., 2018; Kelly et al., 2011). All these hemodynamic measures are associated with poor lipid

profiles and therefore poor metabolic health, including high TG, LDL-C and FBG (da Silva et al., 2017).

The majority of studies on CMDs in child populations use SBP rather than DBP (Kamel et al., 2018). Possible explanations are that tracking-correlation from childhood to adulthood is slightly higher for SBP, and that only SBP may be correlated to CMDs in child populations (Chen & Wang, 2008; Stoner et al., 2017). Only SBP and DBP were available for analysis in this thesis paper.

#### *1.1.5. Physical fitness*

Measures of physical fitness in relation to CMDs revolve around cardio-respiratory fitness. Good physical fitness could be even more important than adiposity in attenuating CMD risk (Brouwer et al., 2013). This is especially true for those overweight or obese (Brouwer et al., 2013). Various tests can be found in the literature, including cycling tests with spirometry to measure VO<sub>2</sub>max and shuttle run tests (Lars Bo Andersen, Hasselstrøm, Grønfeldt, Hansen, & Karsten, 2004; Brouwer et al., 2013). VO<sub>2</sub>max-tests with spirometry is one of the most reliable measures of aerobic endurance, but suffers from requiring resource-demanding equipment. Proxy tests of aerobic capacity are more readily accessible in clinical settings.

The use of validated intermittent running tests such as the *Andersen fitness test* is preferable for reproducibility and reliability (Aadland, Andersen, Lerum, & Resaland, 2017; Aadland, Terum, Mamen, Andersen, & Resaland, 2014; L. B. Andersen, Andersen, Andersen, & Anderssen, 2008). The test requires no special equipment and is suitable for large samples, testing up to ten children at a time (Appendix 5). It is moreover validated as a reliable indicator of VO<sub>2</sub>max for studies on child populations (Aadland, Andersen, Skrede, et al., 2017).

#### *1.1.6. Dietary diversity (for explorative analysis)*

Assessing overall dietary patterns may be more informative than single nutritional components when investigating CMD risk factors. Scores that evaluate overall characteristics of the diet based on food groups give an indication of nutrient adequacy and diet quality. Dietary diversity scores (DDS) reflect either number of major food groups consumed or variety within food

groups. Criteria for the scoring can be based on national dietary guidelines (Helsedirektoratet, 2011).

Consuming a higher number of major food groups has been associated with lower risk of type-2 diabetes, CVD risk, all-cause mortality, and better metabolic health (Conklin, Monsivais, Khaw, Wareham, & Forouhi, 2016; Farhangi & Jahangiry, 2018). There is however some dispute as to whether greater variation in foods consumed is exclusively positive. Higher dissimilarity in food consumption within each major food group has been found to correlate with higher gain in WC in a 5-year cohort (Otto, Padhye, Bertoni, Jr, & Mozaffarian, 2015). Keeping the DDS to major food groups may therefore be more useful than diversity scores within each group.

DDS was included in the thesis-cover's exploratory analyses since it is also an important risk factor. It was kept out of the CMD risk score due to its large behavioral component. This would reduce the score's reliability by introducing unknown confounding variables. Studying the relationship between DDS and disease risk could inform possible public health policy targets by highlighting challenging food groups.

## **1.2. Aims**

The main aim of the master's thesis was to investigate the clustering of risk factors related to CVDs and MetS in a nationally representative Norwegian child population. The secondary aim was to present data on and investigate secular trends in physical health. Contained in these aims was to explore potential benefits in clinical settings and public health policy-making.

The purpose of this "thesis cover" is to supplement with theoretical and methodological aspects not covered in the scientific article. Further, there is an addition of two exploratory analyses following findings in the scientific article and its null-results. The author of this thesis would like to recommend reading the scientific article before continuing.

## 2. Method

### 2.1. Design

The entirety of the Health Oriented Pedagogical Project (HOPP) is a seven year intervention cohort study (Fredriksen, Hjelle, Mamen, Meza, & Westerberg, 2017). Aims of the cohort include investigating health and cognitive outcomes following comprehensive physical activity (PA), dietary and pedagogical capacity building interventions. The school-based intervention program in PA includes increased PA of 225 min/week as an integrated part of the theoretical learning (Fredriksen et al., 2017). As this paper only covers baseline data prior to the intervention, only a brief summary of the main components in the general study design is detailed below.

Project development started in 2013 and the project description was first made available in 2014 (“REK,” 2017). It was approved (following a single revision) by the Regional Committees for Medical and Health Research Ethics (REK) on the 14. January, 2015 (REK ref.no.: 2014/2064), immediately proceeded by data collection of baseline findings (“REK,” 2017). Project leader Professor P.M. Fredriksen spearheads the HOPP-research.

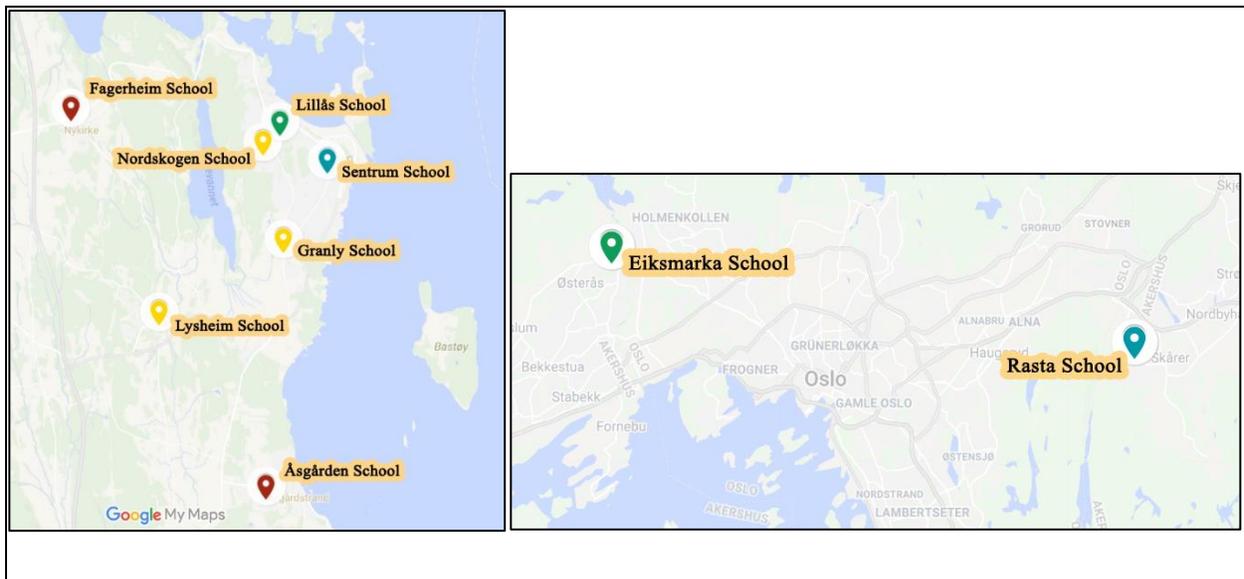
Outcomes of the study include physiological, psychological, and academic variables. That is, anthropometry, body composition, physical fitness, blood samples (micronutrients, blood lipids, and micro C-reactive protein), executive cognitive function, dietary habits, and psychological health (e.g. inventory of life quality). All tests were administered at the children’s schools in gyms or classrooms.

Additional aims of the study, aside from physical and psychological health following the intervention, is to inform future public health measures aimed at children in primary education. Findings through the HOPP-study will help shape the future of pedagogical methods that include physical activity as part of the curriculum.

This paper only covers baseline findings (collected January-June 2015) with a cross-sectional design. The STROBE-checklist ensured the quality of this paper (Lachat et al., 2016). Findings from the thesis could provide insights on health risk assessment both in clinical settings and for public health interventions.

## 2.2. Sample

The study population consisted of nine elementary schools, seven in Horten municipality and two in Akershus county (Figure 1). Intervention schools were those in Horten municipality and control schools in Akershus county. Eiksmarka and Rasta school were included based on comparable socioeconomic levels to the intervention schools. A centralized Norwegian program for systematic quality work in schools was used for identifying the control schools (“Conexus Insight (formerly PULS),” 2018). The entire population was however treated as a single population for the purposes of this thesis.



Left: Horten municipality. Right: Oslo municipality

Figure 1: Map over location of schools included in the study

School registries were used for recruitment (aged 6-12 years,  $n=2816$ ). 2302 children had informed consent from parents and guardians, representing a response rate of 82%. Lowest response rate was found among the 6-year olds at 75% and highest at 88% among the 12-year olds.

### 2.3. Recruitment and information

Written information, informed consent forms, pamphlets, social media interaction, and a website regarding HOPP were given to parents by Horten municipality in 2014 (Appendix 1, 2, and 3). The study team gave additional information to parents at school meetings. Control schools were not informed of the school-based PA intervention.

### 2.4. Data collection

The test-staff was primarily recruited from students at colleges and universities. A member of the research-team taught procedures and equipment prior to data collection. It was preferable with up to eight testers each day depending on number of children at the school. An experienced test leader was always present as a coordinator.

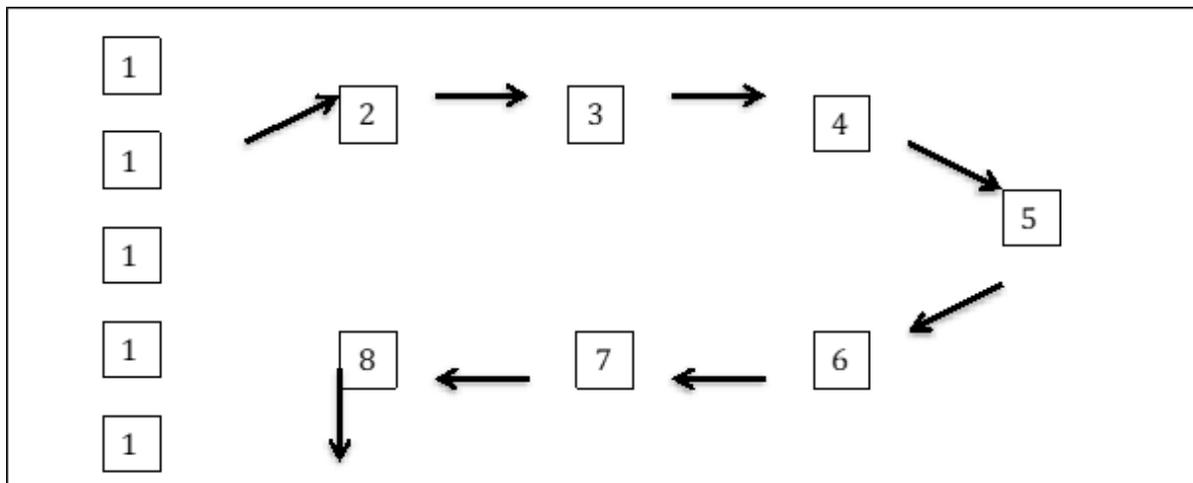


Figure 2: Approximation of test setup at each school.

The figure shows the various stations for the gym/classroom-based tests.

Station 1 were the questionnaires and cognitive tests (executive cognitive function, life quality, diet), 2 = blood pressure, 3 = waist circumference and height, 4 = body composition, 5 = aerobic capacity, 6 = handgrip strength, 7 = balance, 8 = spirometry.

Classrooms and gyms provided by the respective schools were used for anthropometry and body composition. The children were upon arrival given a folder containing a form with only an ID number (Appendix 4). They were taught to keep it closed and with them at all times as they

moved to each measurement station (Figure 2). All measurements were registered in the form by the test-team. The folder was handed back before exiting the venue.

## **2.5. Statistical analyses**

### *2.5.1. Quartile divisions*

Included participants for statistical analyses had valid measurements for all six variables; WC, SBP, HbA1c, TC, HDL-C, and the Andersen fitness test (L. B. Andersen et al., 2008). Exclusion of all with missing data prevents misrepresentation within each risk score.

Quartile divisions determined cut-offs. Those in the quartile deemed least desirable was coded as having one risk factor (per variable). That means, highest quartile for WC, SBP, HbA1c, and TC/HDL ratio, and lowest for the Andersen fitness test. The Andersen fitness test was inverted compared to the rest since those who ran the shortest distance were considered the least physically fit.

A combination of theoretical and statistical approaches were employed to determine the least desirable quartiles. The theoretical evaluation consisted of expert consultations, investigating existing reference values, a review of the available literature, and reports from The Norwegian Directorate of Health on major challenges pertaining to the CMD risk variables (Helsedirektoratet, 2009b; Helsedirektoratet, 2009a; Nasjonal folkehelseinstitutt, 2018).

Statistical analyses included evaluating sample distributions around the mean along with histograms, both total and stratified by age. Sample skews provided information on whether the lower or upper end of the distribution were furthest away from the median scores. This gave an idea as to where the main challenges could be.

### *2.5.2. Data cleaning*

Each variable was checked and cleaned for input errors. Outliers were not systematically removed as this would undermine the core purpose of this thesis; to identify those most in risk of CMDs. WC and SBP was divided in quartiles with no additional processing. Proper training of test personnel and good routines ensured stability of these instrument-based measurements. The Andersen fitness test results were checked for outliers that indicated the participant had given up

on the test or had an invalid run. The whole sample was split in quartiles for HbA1c, TC, and HDL-C since stringent hospital procedures ensured high validity of measurements and that blood samples are stable measures.

### 2.5.3. Binomial probability distribution

Original number of risk factors for the binomial probability function was ten: WC, TC, HDL-C, HbA1c, Andersen fitness test, BMI, muscle mass, percentage fat, non-HDL cholesterol, and mCRP (Fredriksen et al., 2017). SBP and WHtR were included as a result of literature search results (Abarca-Gómez et al., 2017, 2017; Chung et al., 2016; T. J. Cole & Lobstein, 2012; Kamel et al., 2018). The probability distribution would be as presented in Table 1.

Table 1: Binomial probability distribution at 10, 6, and 5 independent trials

Number of successes	Factors probability mass		
	10 factors	6 factors	5 factors
1	18.77%	35.60%	39.55%
2	28.16%	29.66%	26.37%
3	25.03%	13.18%	8.79%
4	14.60%	3.30%	1.46%
5	5.84%	0.44%	0.10%
6	1.62%	0.02%	
7	0.31%		
8	0.04%		
9	0.0029%		
10	0.0001%		

Distributions assumes a probability of 0.25% for each “success”.

Ten factors would result in a less than 1% probability of presenting with  $\geq 7$  risk factors (Table 1). There is little clinical relevance to four risk scores at such a low detection rate. Collating them in a single 7+ group would moreover lower the specificity of the CMD risk score.

A probability distribution with six factors still left two categories below 1%. Five factors were therefore selected following a Pearson's correlation analysis of all included variables. In other words, two children were expected to have five risk factors due to random probability among the initial 2302 children.

Variables were selected based on ease of measure and versatility, correlating  $-0.7 \geq r \geq 0.7$  with the highest number of variables.

## **2.6. Explorative analysis: Clustering of CMD risk factors**

Explorative analyses were performed for the thesis-cover following findings presented in the scientific article. The cut-off value itself was included in the least desirable quartiles for all variables, not only for the Andersen fitness test.

Though results showed no significant clustering of CMD risk factors, the margins to significant clustering at four factors were small. Results of the exploratory analysis would not serve to prove any hypotheses but might support the claim that larger sample sizes could result in significant clustering.

The mathematical proof holds by using a different definition for quartile divisions. The original quartile division does not include the cut-off itself, but includes it in the lower quartile. Tukey's method however assumes that the 1<sup>st</sup> and 4<sup>th</sup> quartiles include the cut-offs with the median value as the pivot of the division (Weisstein, 2018). This minor change could significantly affect for example HbA1c since a naturally low variance was expected for this value.

## **2.7. Explorative analysis: Dietary patterns and CMD risk**

Dietary patterns were analyzed to explore possible associations with CMD risk. The food frequency questionnaire (FFQ) is a validated form developed for national surveys named Ungkost-2000 (Appendix 6, question 6 on smoking excluded) (Hansen, Myhre, Johansen, Paulsen, & Andersen, 2016; Øverby & Andersen, 2002). The questions were based on a typical Norwegian diet. Questions included frequency of food items, dietary restrictions, weight satisfaction, self-perceived health, and meal patterns. Food categories were vegetables, breads, dairy, fish, fast-food, meats, sweets, and vitamins. The questionnaire was administered by use of computers.

Sample was limited to fourth-graders only since it is only validated for this age-group (Øverby & Andersen, 2002). The limited sample size renders it only suitable for explorative analyses in this thesis.

Question 17 regarding consumption frequency of vegetables, fruits and berries, wholegrain bread, and fish for dinner were collated to a single DDS. Norwegian national guidelines on consuming at least five vegetables, fruits, or berries per day, increased fiber intake, and fish for dinner at least twice a week formed the foundation for the coding of DDS (Helsedirektoratet, 2011). That is, number of categories consumed at least 4-6 times/week for vegetables, fruits and berries, and wholegrain bread, and for fish at least 1-3 times/week. The higher the score the more diverse their diet.

Bar graphs and line diagrams illustrated patterns in CMD risk score by DDS.

## **2.8. Contributions and expenses**

Contributions for the scientific article was as follows:

WHD and PMF developed the theory for this research paper. WHD did the literature searches, developed the statistical analysis plan, cleaned and analyzed the data, and wrote the drafts and final manuscript. PMF, ML, OPH, AM provided feedback and verified the final manuscript. PMF encouraged WHD throughout the writing process, devised the HOPP research protocol and its main conceptual ideas, supervised the HOPP research project and this thesis paper, monitored data collection throughout the project period, and provided feedback on the statistical analysis plan. PMF, ML, OPH, AM contributed to the design and implementation of the HOPP research project. WHD, PMF, ML, OPH, AM contributed to data collection.

Key: WHD = Wei Hai Deng; ML = Morten Lindberg; OPH = Ole Petter Hjelle;  
AM = Asgeir Mamen; PMF = Per Morten Fredriksen.

Primary funding sources are Horten municipality, providing funds for equipment purchases, and Kristiania University College for equipment, testing staff, and researchers to analyze and publish test results.

### **Master's thesis external advisor:**

Per Morten Fredriksen (PT, MSc, PhD)

Professor, HOPP Project Leader

Department of Health Sciences, Kristiania University College

[permorten.fredriksen@kristiania.no](mailto:permorten.fredriksen@kristiania.no)

**Master's thesis internal advisor:**

Asgeir Brevik (MSc, PhD)

Associate Professor

Faculty of Health Sciences, Oslo Metropolitan University

[asgeir.brevik@oslomet.no](mailto:asgeir.brevik@oslomet.no)

### 3. Results

The following results chapters detail the statistical analyses that formed the basis of the clustered CMD risk score (chapters 3.2 to 3.5). The last two chapters (chapters 0 and 0) are additional exploratory analyses to the original statistical analysis plan.

#### 3.1. Sample distribution

After only including those with all six valid measurements from the HOPP-sample, 1056 children of 6 to 12 years old were included in the final analyses (table 2). Average age difference between each age group was 0.94 (SD = 0.09) (table 4). The majority of the sample were from Horten municipality (65%) (table 2).

Table 2: Frequency and percentage distribution of sample by school

School	n	% of n
Lysheim School	68	6.4%
Granly School	120	11.4%
Fagerheim School	58	5.5%
Åsgården School	59	5.6%
Lillås School	121	11.5%
Nordskogen School	103	9.8%
Sentrum School	158	15.0%
Rasta School	129	12.2%
Eiksmarka School	240	22.7%
<b>Total</b>	<b>1056</b>	<b>100.0%</b>

#### 3.2. Selecting factors/correlation analysis

The correlation analysis coincidentally resulted in five risk factors. This was exactly the desired number of risk factors based on a binomial probability distribution (Table 1). Two notable groups with high correlations ( $r \geq 0.7$ ) could be found in Table 3, first group includes WC, BMI, MM, %F, and WHtR, the second is TC and non-HDL-C (Cohen, 1988). This leaves SBP moderately correlating with WHtR ( $r \geq 0.5$ ). Andersen aerobic fitness, HbA1c, HDL-C, and micro C-reactive protein (mCRP) only weakly correlated with other variables ( $r < 0.5$ ) and were,

with the exception of mCRP, included in the CMD risk score. The final factors in the cluster analysis were WC, SBP, Andersen aerobic fitness, HbA1c, and TC/HDL-ratio.

Table 3: Correlation matrix of risk factors for cardiovascular and metabolic diseases.

	WC	SBP	Andersen	HbA1c	TC	HDL-C	non-HDL-C	BMI	MM	%F	mCRP	WHtR
WC	1	0.27*	0.08*	0.04	0.06*	-0.19*	0.17*	0.86*	0.77*	0.66*	0.06	0.75*
SBP	0.27*	1	0.19*	0.02	0.07*	0.02	0.06*	0.24*	0.35*	0.11*	0.01	0.63*
Andersen	0.08*	0.19*	1	0.12*	-0.05	0.09*	-0.10*	0.00	0.38*	-0.22*	-0.08	-0.30*
HbA1c	0.04	0.02	0.12*	1	0.08*	0.03	0.06*	0.03	0.05	-0.01	0.00	0.01
TC	0.06*	0.07*	-0.05	0.08*	1	0.26*	0.86*	0.08*	-0.02	0.16*	-0.04	0.10*
HDL-C	-0.19*	0.02	0.09*	0.03	0.26*	1	-0.28*	-0.22*	-0.14*	-0.23*	-0.09*	-0.19*
non-HDL-C	0.17*	0.06*	-0.10*	0.06*	0.86*	-0.28*	1	0.20*	0.05	0.28*	0.00	0.20*
BMI	0.86*	0.24*	0.00	0.03	0.08*	-0.22*	0.20*	1	0.71*	0.76*	0.11*	0.72*
MM	0.77*	0.35*	0.38*	0.05	-0.02	-0.14*	0.05	0.71*	1	0.33*	-0.01	0.21*
%F	0.66*	0.11*	-0.22*	-0.01	0.16*	-0.23*	0.28*	0.76*	0.33*	1	0.19*	0.68*
mCRP	0.06*	0.01	-0.08	0.00	-0.04	-0.09*	0.00	0.11*	-0.01	0.19*	1	0.12*
WHtR	0.75*	0.63*	-0.30*	0.01	0.10*	-0.19*	0.20*	0.72*	0.21*	0.68*	0.12*	1

All correlations are Pearson's r.

Blue indicates correlations < 0.2; yellow indicates correlations ≥ 0.2; red indicates correlations ≥ 0.5; green indicates correlations ≥ 0.7.

WC = waist circumference; SBP = systolic blood pressure; Andersen = Andersen fitness test; HbA1c = hemoglobin-A1c; TC = serum total cholesterol; HDL-C = serum high density lipoprotein cholesterol; BMI = body mass index; MM = muscle mass; %F = fat percentage; mCRP = micro C-reactive protein; WHtR = waist-to-height ratio.

\* p < 0.05

### 3.2.1. A word about mCRP

mCRP was only significantly different and outside normal ranges for those overweight or obese, and further for only a small number of participants (owing to a narrow variance). Including mCRP would limit findings to only those above normal weight. The measure was therefore ruled out *a priori* since the purpose of this paper was to investigate early signs of future disease risk also among those with normal BMIs.

### 3.2.2. Adiposity and hemodynamic measures

WC had a moderate or high correlation (p < 0.05) to BMI (r = 0.86), MM (r = 0.77), %F (r = 0.66), and WHtR (r < 0.75) (Table 3). It makes little theoretical sense to use BMI, as it was originally a measure intended for adults. Z-score for BMI by age and sex or Cole et al.'s isoBMI

for children and adolescents would make better sense but is limited as a measure of central adiposity (T. J. Cole & Lobstein, 2012; Tim J. Cole, Bellizzi, Flegal, & Dietz, 2000). MM and %F are limited to those with access to bioelectric impedance instruments. WC and WHtR are much more accessible in comparison.

Multicollinearity may be an issue with WHtR since it moderately correlates with SBP, the only hemodynamic measure. WC was therefore the strongest candidate for central adiposity and SBP for hemodynamic measures.

### *3.2.3. Blood lipids*

Total cholesterol's association with non-HDL was expected since it was calculated by subtracting HDL-C from TC (Table 3). A collated measure of TC/HDL-ratio represented both TC and HDL. Non-HDL was therefore unnecessary in favor of a TC/HDL-ratio.

## **3.3. Assessing age and sex divided cut-off values**

The proceeding results support age and sex stratified quartile divisions rather than dividing the whole sample by age or sex alone. All CMD risk variables had some age and sex differences. Risk factors were therefore split in quartiles by both age and sex. This conclusion is even further supported by the different final cut-offs shown in table 5.

### *3.3.1. Age differences in CMD risk factors*

Among all measures, weight, height, BMI, WC, all body composition except percentage body fat, and all cardiopulmonary variables, were significantly higher with increasing age in a one-way ANOVA ( $p < 0.0001$ ) (table 4). WHtR ( $p < 0.0001$ ) and HbA1c ( $p < 0.05$ ) also differed significantly between the age groups. Post-hoc Bonferroni analysis revealed that the differences in WHtR were between the youngest (6 and 7 year olds) and oldest (11 and 12 year olds) children ( $p < 0.05$ ), where the lowest ratio were among the older children. Post-hoc Bonferroni revealed no significant age differences in HbA1c.

Table 4: Descriptives of anthropometry, body composition, cardiopulmonary variables, and blood samples among 6-12 year olds

	6		7		8		9		10		11		12		p-value for trend
	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)	
<b>Age (years)</b>	88	6.64 (0.24)	135	7.52 (0.27)	159	8.48 (0.29)	176	9.49 (0.26)	184	10.47 (0.27)	230	11.49 (0.29)	84	12.25 (0.18)	
<b>Anthropometry</b>															
<b>Weight (kg)</b>	88	23.35 (3.47)	135	26.45 (4.12)	159	29.26 (5.19)	176	32.77 (6.77)	184	36.62 (7.16)	230	40.84 (8.17)	84	43.11 (7.60)	<0.0001
<b>Height (cm)</b>	88	1.22 (0.05)	135	1.28 (0.06)	159	1.34 (0.06)	176	1.39 (0.06)	184	1.43 (0.07)	230	1.50 (0.07)	84	1.54 (0.07)	<0.0001
<b>BMI (kg/m<sup>2</sup>)</b>	88	15.51 (1.55)	135	15.98 (1.81)	159	16.24 (2.07)	176	16.90 (2.48)	184	17.73 (2.90)	230	17.94 (2.73)	84	17.99 (2.28)	<0.0001
<b>Waist (cm)</b>	88	56.95 (4.61)	135	59.25 (5.40)	159	60.50 (5.35)	176	62.88 (7.22)	184	65.51 (7.90)	230	67.10 (7.97)	84	67.97 (6.41)	<0.0001
<b>WHtR</b>	88	0.47 (0.03)	135	0.46 (0.04)	159	0.45 (0.04)	176	0.45 (0.04)	184	0.46 (0.05)	230	0.45 (0.05)	84	0.44 (0.04)	<0.0001
<b>Body composition</b>															
<b>Muscle mass (kg)</b>	87	17.57 (2.19)	134	19.71 (2.50)	159	21.79 (3.12)	175	24.27 (3.67)	183	26.95 (3.88)	229	30.19 (4.61)	84	32.35 (4.49)	<0.0001
<b>Fat (%)</b>	87	19.94 (3.34)	134	20.77 (4.12)	159	20.74 (4.35)	175	20.87 (5.13)	183	21.50 (4.95)	229	20.99 (5.57)	84	20.23 (4.74)	0.229
<b>Fat mass (kg)</b>	87	4.73 (1.43)	134	5.60 (1.92)	159	6.18 (2.29)	175	7.10 (3.47)	183	8.16 (3.61)	229	8.88 (4.10)	84	8.94 (3.57)	<0.0001
<b>Fat-free mass (kg)</b>	87	18.60 (2.29)	134	20.86 (2.63)	159	23.04 (3.28)	175	25.72 (3.82)	183	28.41 (4.03)	229	31.87 (4.89)	84	34.13 (4.72)	<0.0001
<b>Bone mass (kg)</b>	87	1.05 (0.13)	134	1.16 (0.15)	159	1.25 (0.18)	175	1.39 (0.20)	183	1.51 (0.21)	229	1.68 (0.25)	84	1.78 (0.23)	<0.0001
<b>Protein mass (kg)</b>	87	3.94 (0.50)	134	4.44 (0.57)	159	4.92 (0.72)	170	5.82 (3.89)	183	6.12 (0.89)	229	6.88 (1.07)	84	7.36 (1.04)	<0.0001
<b>Cardiopulmonary</b>															
<b>SBP (mmHg)</b>	88	103.45 (9.57)	135	105.17 (10.59)	159	107.51 (9.30)	176	108.74 (9.20)	184	110.71 (9.99)	230	111.70 (10.42)	84	113.57 (11.07)	<0.0001
<b>DBP (mmHg)</b>	88	67.36 (8.94)	135	69.02 (7.11)	159	70.99 (7.55)	176	70.84 (7.70)	184	72.39 (7.27)	230	72.45 (7.10)	84	71.86 (5.86)	<0.0001
<b>Andersen test (m)</b>	88	775.69 (109.78)	135	851.59 (108.26)	159	926.84 (121.63)	176	965.83 (121.30)	184	993.68 (123.43)	230	1022.26 (109.79)	84	1084.70 (106.82)	<0.0001
<b>Blood samples</b>															
<b>HbA1c (%)</b>	88	5.32 (0.19)	135	5.35 (0.28)	159	5.39 (0.20)	176	5.41 (0.37)	184	5.35 (0.24)	230	5.39 (0.22)	84	5.42 (0.23)	<0.05
<b>TC (mmol/L)</b>	88	4.20 (0.66)	135	4.24 (0.64)	159	4.34 (0.67)	176	4.38 (0.67)	184	4.40 (0.69)	230	4.28 (0.62)	84	4.25 (0.65)	0.090
<b>HDL-c (mmol/L)</b>	88	1.61 (0.36)	135	1.67 (0.37)	159	1.67 (0.33)	176	1.65 (0.37)	184	1.63 (0.32)	230	1.61 (0.34)	84	1.63 (0.32)	0.623
<b>nonHDL-c (mmol/L)</b>	88	2.60 (0.66)	135	2.57 (0.64)	159	2.68 (0.64)	176	2.74 (0.68)	184	2.77 (0.70)	230	2.66 (0.62)	84	2.62 (0.66)	0.102
<b>TC/HDL-c ratio</b>	88	2.72 (0.64)	135	2.65 (0.71)	159	2.69 (0.61)	176	2.78 (0.68)	184	2.78 (0.63)	230	2.75 (0.67)	84	2.70 (0.66)	0.563
<b>mCRP (mg/L)</b>	38	1.58 (2.37)	62	1.59 (3.36)	62	1.04 (2.28)	78	0.91 (1.69)	74	1.05 (1.91)	92	1.09 (2.04)	44	0.60 (2.10)	0.294

\* BMI = body mass index; WHtR = waist-to-height-ratio; SBP = systolic blood pressure; DBP = diastolic blood pressure; HbA1c = hemoglobin-A1c, TC = total serum cholesterol, HDL-c = serum high-density-lipoprotein cholesterol, nonHDL-c = serum non-high-density-lipoprotein cholesterol; TC/HDL-c ratio = serum total cholesterol to high-density-lipoprotein cholesterol = ratio; mCRP = micro C-reactive protein.

\* Only those with six valid measures of the CMD risk factors are included in this table.

\* p-value for trend shows a one-way ANOVA by age.

### 3.3.2. Sex differences in CMD risk factors

Boys in the sample had higher mean WC, SBP ( $\Delta\mu = 1.6$  mmol/L, 95% CI = 0.4-2.9,  $p < 0.05$ ), Andersen test results ( $\Delta\mu = 35$  m, 95% CI = 18-52,  $p < 0.0001$ ), and HbA1c. A t-test revealed no significant differences in mean WC ( $p = 0.137$ ) and HbA1c ( $p = 0.553$ ) between boys and girls.

### 3.3.3. Age and sex differences in CMD risk factors

Mean SBP and Andersen results among boys were higher than the girls' in all age groups. Mean WC were higher among boys in the 6- and 11-year-olds in this sample. Age-divided sex analyses revealed significant general differences in WC among the 10- and 12-year-old boys and girls ( $p < 0.05$ ). Significant differences in SBP were found among the 8-year-olds ( $p < 0.01$ ). Significant differences in Andersen fitness test results were among the 9-11-year-olds ( $p < 0.05$ ).

Girls had higher mean TC/HDL-ratio in all age groups in the sample. Average difference of means among boys and girls were significant ( $p < 0.0001$ ) by 0.2 (95% KI = 0.1-0.3). Age-divided analyses showed significant differences among the 6-, 8-, 9-, and 11-year-olds ( $p < 0.05$ ).

## 3.4. Quartile divisions

Judging histogram distributions by age and sex (figure 3), both WC and TC/HDL-ratio are clearly right-skewed, while Andersen aerobic fitness test results are left-skewed. These place outlying values more likely to the right and left of the median respectively. These sides were therefore, in conjunction with literature reviews, used as the least desirable quartiles (L. B. Andersen et al., 2008; Dalene et al., 2017; Helsedirektoratet, 2010; Hui, Liu, & Ho, 2010; Lemieux et al., 2001). Systolic blood pressure was more evenly distributed on both tails. The fact that hypertension is a likely contributing factor to cardiovascular diseases places the least desirable quartile in the upper quartile (Chiu et al., 2016; Folkehelseinstituttet, 2016; "IDF," 2015). HbA1c has as expected a small variance and was supported by the stable cut-off values across all age groups and both sexes (Table 5). Seeing as high fasting blood sugar level is one of the indicators of diabetes, the upper quartile was used as the least desirable quartile ("IDF," 2015).

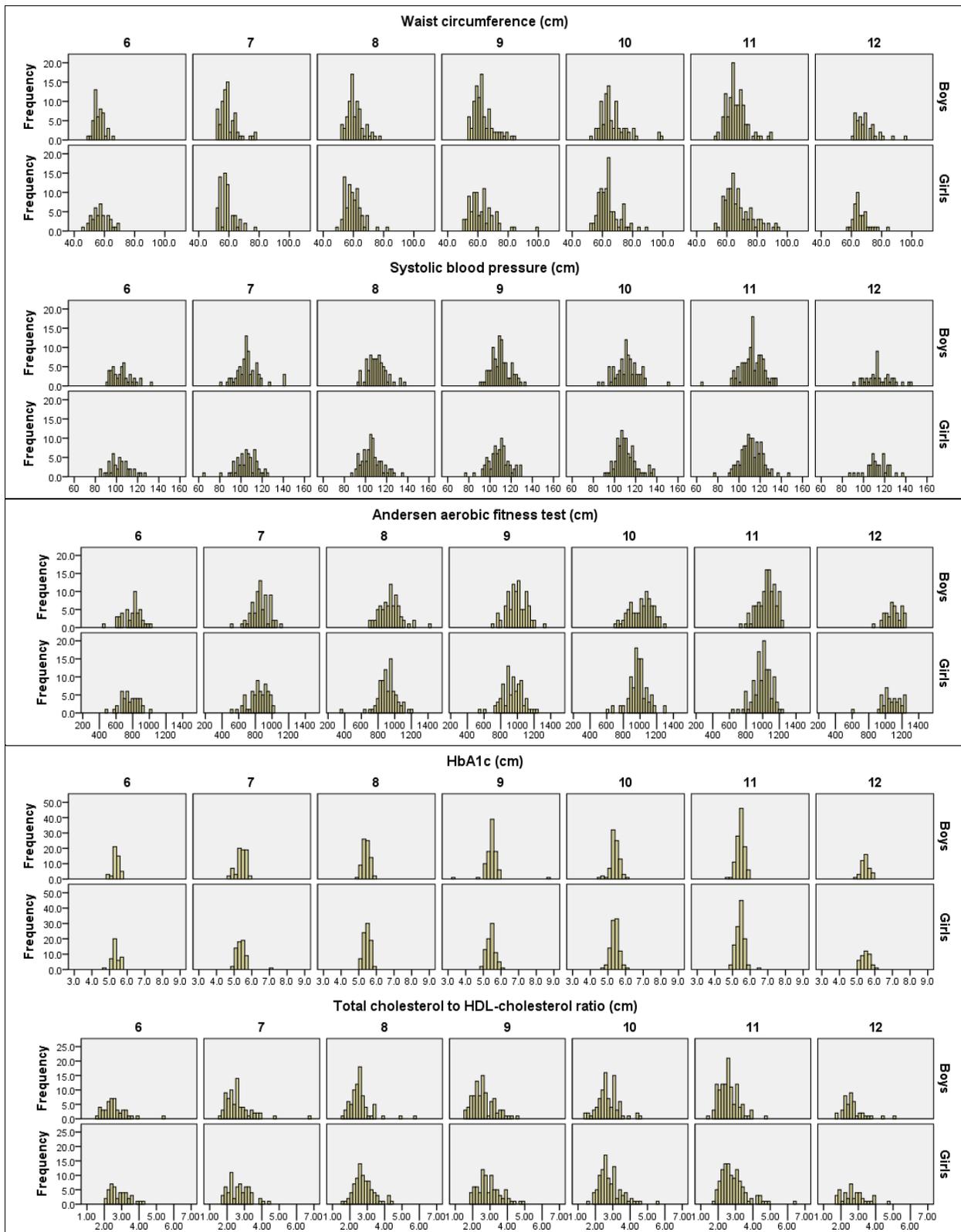


Figure 3: Histograms of cardiometabolic risk factors by age and sex divisions

Cut-off values were determined by assuming an ascending division of the quartiles, meaning the cut-off value itself was included in the lower quartile (table 5). Both HbA1c and TC/HDL-ratio cut-offs were stable across all age groups. Cut-off values for WC, SBP, the Andersen fitness test increased with increasing age.

Table 5: Cardiometabolic risk score cut-off values based on quartiles by age and sex

Sex and age	WC > (cm)	SBP > (mmol/L)	Andersen ≤ (m)	HbA1c > (%)	TC/HDL-ratio >
<b>Boys</b>					
6	58.4	109	721	5.4	2.9
7	62.6	110	799	5.6	2.9
8	64.0	114	860	5.5	2.7
9	66.8	115	910	5.6	3.0
10	70.0	118	900	5.5	3.1
11	70.0	119	981	5.5	2.9
12	73.0	123	1038	5.6	2.8
<b>Girls</b>					
6	61.5	109	698	5.5	3.3
7	60.0	112	780	5.5	3.1
8	62.4	110	855	5.6	3.1
9	66.4	113	871	5.5	3.3
10	66.5	116	920	5.5	3.1
11	73.0	118	940	5.5	3.2
12	69.0	119	1020	5.6	3.1

\* WC = waist circumference; SBP = systolic blood pressure; Andersen = Andersen aerobic fitness test; HbA1c = hemoglobin-A1c, TC/HDL-ratio = serum total cholesterol to high-density-lipoprotein ratio.

\* Cut-offs are based on quartile divisions stratified by age and sex.

### 3.5. Cardiometabolic risk score

Most of the children scored only one CMD risk factor (38.3%). 28.8% had zero risk factors. 2.3% of the sample scored four and 0.6% five risk factors, of which most of those with five risk factors were nine years old. None of those six, seven, 10, and 12 years old had five risk factors, and none of the six years old had four or more risk factors (figure 4). Median CMD risk score was one for all age groups.

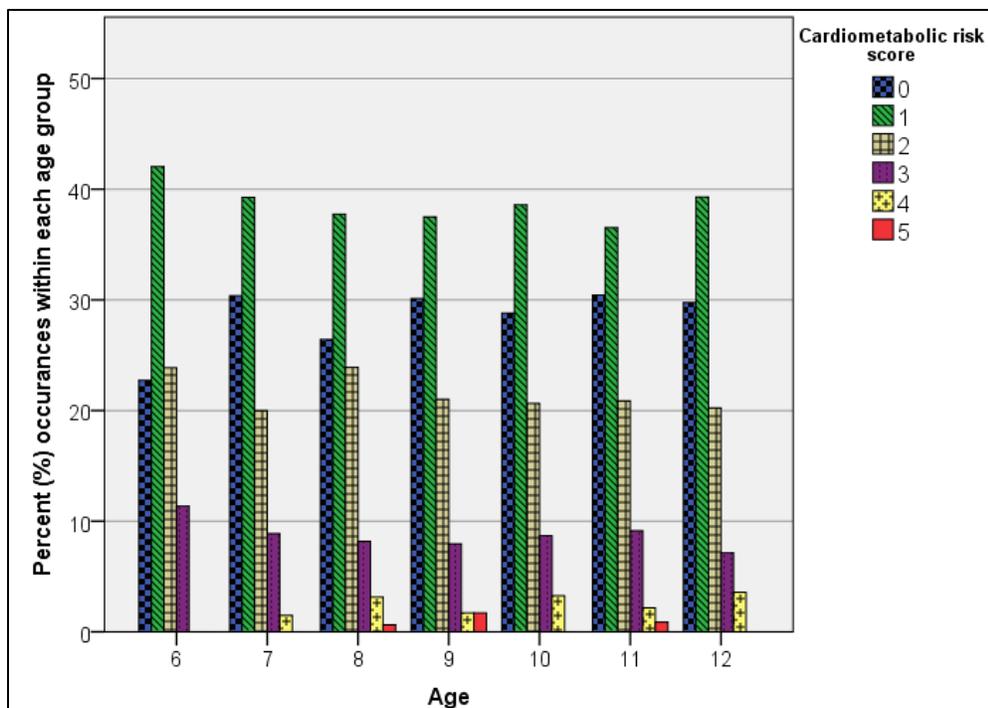


Figure 4: Clustered bar chart with distribution of cardiometabolic risk scores split by age.

To supplement the article-findings, table 6 shows averaged sum of the absolute value of the z-scores in each CMD risk category. While the article’s aim was to present specific data for the included CMD risk variables, the numbers in table 6 may instead allow study comparisons even when correlates of the variables included in this paper are used.

Table 6: Mean sum of absolute values of z-scores by CMD risk score

CMD risk score	Mean z-score (SD)
0	0.0 (0.0)
1	1.2 (0.7)
2	2.4 (1.0)
3	4.0 (1.3)
4	5.9 (1.9)
5	8.3 (3.0)

\* CMD = Cardiometabolic disease

### 3.6. Explorative analysis: Clustering of CMD risk factors

The scientific article of this thesis found no clustering of CMD risk factors at any CMD risk score, thwarted by large margins of error at four and five factors. Figure 5 shows relative risk to an expected binomial probability distribution using revised cut-offs. As can be seen, children in the zero and one risk factor groups were reallocated to the two or more risk factor groups. As a result there is a significant clustering at three (RR = 1.3, 95% CI = 1.0-1.7) and four (RR = 2.7, 95% CI = 1.5-4.7) risk factors. There were no changes from the original findings at five risk factors.

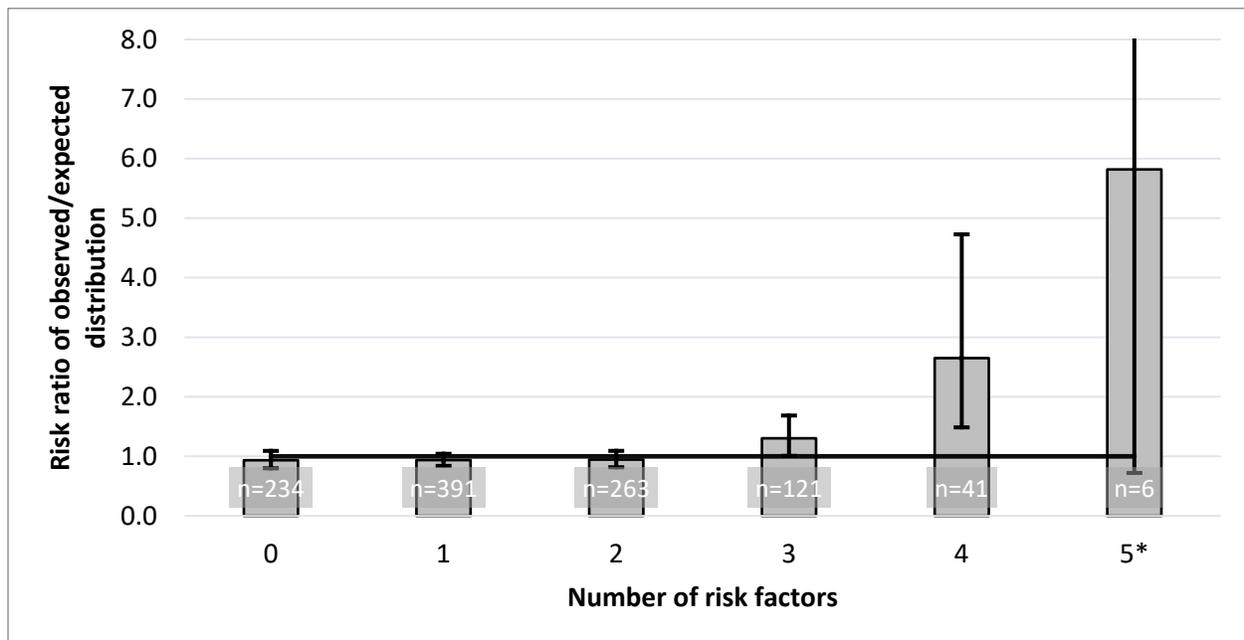


Figure 5: Explorative analysis: relative ratio of observed/expected distribution by number of cardiometabolic risk factors.

Distribution of observed number of cardiometabolic risk factors in least favourable quartile against a binomial probability distribution. Any significant values above 1.0 indicates a clustering of risk factors.

\* RR = 1.30, 95% CI = 1.01-1.69.

\*\* RR = 2.65, 95% CI = 1.49-4.73.

\*\*\* RR = 5.82, 95% CI = 0.72-46.93.

### 3.7. Explorative analysis: Dietary diversity and CMD risk score

There were 97 nine-year-olds and 70 ten-year-olds among those with both valid CMD risk measurements and dietary diversity scores (n = 167). Most children had a DDS of three (34%) or four (30%) (Figure 6).

Children with four CMD risk factors all had a DDS of three and those with five risk factors all scored a DDS of four (Figure 6). Most of those with zero risk factors had a score of three in DDS, which was also median DDS. It is not clear which major food group was lacking in their diet, but wholegrain bread was the main lacking category across all DDSs.

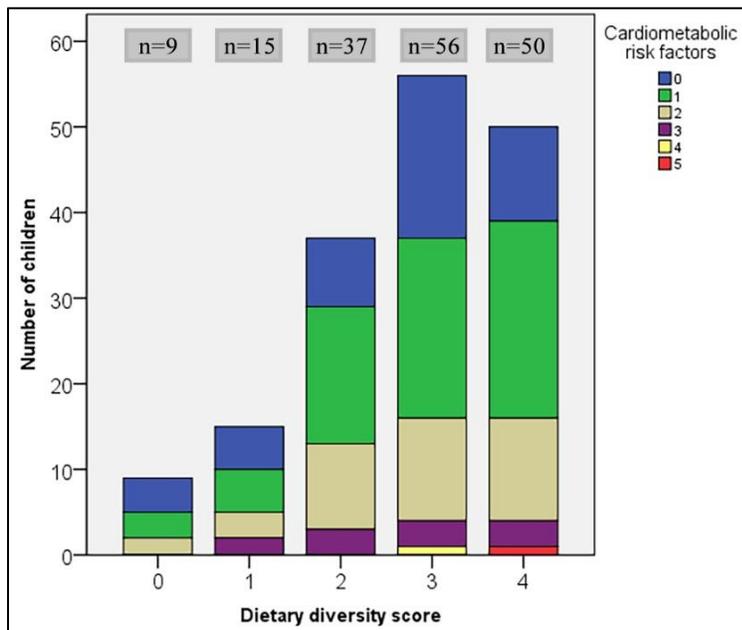


Figure 6: Bar graph of CMD risk factor frequency by dietary diversity score.

## 4. Discussion

### 4.1. Defining the risk of cardiometabolic disease and clinical applicability

In addition to studying clustering above an expected distribution, this thesis wanted to provide a potential risk assessment tool related to both CVDs and MetS in children. The presence of multiple factors equates to an elevated risk of developing CMDs (Lars Bo Andersen et al., 2015). Whether the consolidated score correlates with CMDs or if they are just a mixture of unrelated phenotypes is, however, dependent on large longitudinal cohorts.

The analytical model in this study examined whether the clustering of factors occurred together more than by chance, in which case it would be plausible to assume underlying causes (Lars Bo Andersen et al., 2015). Early detection of such clustering with proper follow-ups can significantly reduce the risk of CMDs (Barstad et al., 2018; Bugge et al., 2013; van Vliet et al., 2011). As such, health practitioners can benefit from a validated definition to administer suitable care.

Challenges of a continuous CMD risk score are relatable to the defining of MetS criteria. The MetS has multiple standards, which include the IDF's, the American Heart Association's (AHA) and the National Cholesterol Education Program's (NCEP) ATP-III definition and many more ("NHLBI," 2001; "AHA," 2018; "IDF," 2015; Huang, 2009). Though all are similar in that they require a minimum number of risk factors, the components themselves differ greatly. Cut-points in each are different, not all require diagnosis of type-2 diabetes, the use of fasting glucose vary, the IDF definition places greater emphasis on central obesity, not all include specific instructions by ethnicity or sex, and so on. These differences lead to diverging prognostic ability and identification of cases.

A benefit of the selection process of risk factors in this thesis was the exclusion of covariates. This means that each included variable is likely a unique identifier for the risk of CMDs. The same methodological approach in an adult sample would further validate the method with hazard ratio analyses (Selmer et al., 2017). The addition of reporting strong and moderate correlations to each variable allows more flexibility in study comparisons as well as more versatility in clinical use (Table 3).

An important question that remains is whether CMD risk *should* be defined in child populations. In the case of MetS, a three-year follow-up found instability in the diagnosis of adolescents (Goodman et al., 2007). The study found that different stages of growth and development required different diagnostic thresholds. These findings along with the varying MetS definitions highlight two challenges: different diagnostic factors may be required at different life-stages, and the population-specific nature of defining cut-points, whether dichotomously or as ordinal variables.

Background variables such as age, sex, ethnicity, and socioeconomic status may confound the current findings. The current CMD risk factors agree with previous findings where BP, adiposity, and cholesterol loaded onto the same factor (Stoner et al., 2017). In addition, HbA1c loaded onto adiposity and was indicative of overweight-obesity in children. However, while a strength of this study is the large sample size, a wide variability in background variables may hide e.g. age and sex specific differences in the CMD risk definition. The single-point data does, unfortunately, not allow investigating stability of the CMD risk score prospectively (Ahrens et al., 2014; Goodman et al., 2007; Magge et al., 2017). Overweight and obesity prevalence, for example, differ across socio-demographic groups (Júlíusson et al., 2010). Longitudinal economic changes affect risk of CVDs differently across varying strata of socioeconomic status (Jackson, Yang, & Zhang, 2018). Even perceptions of diabetes risk factors differ greatly among ethnic minorities in Norway (Kjøllestadal, Hjellset, Bjørge, Holmboe-Ottesen, & Wandel, 2011). It may be prudent to define age-, sex-, and even ethnicity-, and socioeconomic status-specific cut-points.

The use of clustering of CMD risk as a continuum of risk (risk score 0-5) may mitigate some of the diagnostic limitations. A continuous risk score, rather than dichotomously defining risk, better reflects the continuous nature of the risk factors. A continuous risk score enables better administration of care to high-risk individuals in tiers. All included risk factors are at least known factors to CMDs. In other words, use of a continuous risk score may be better suited for use in pediatric practice and public health policy-making.

## 4.2. Preventive care in public health

### 4.2.1. *Identifying the target population of preventive care*

Initial findings from this thesis indicate no significant clustering of CMD risk factors among Norwegian children 6-12 years of age. The exploratory analysis however reflects previous findings in Norway and Denmark better (Figure 5) (L. B. Andersen, Wedderkopp, Hansen, Cooper, & Froberg, 2003; Steene-Johannessen et al., 2009). There may be a clustering of CMD risk factors among those with four factors.

Most notable were the changes in the three and four risk factor groups where 95% confidence intervals now indicate significant clustering at three or more risk factors. Results at three risk factors are nearly not clinically relevant and only statistically significant at two decimal places. There was a more significant clustering at four risk factors. If so, targeting the four percent who had four risk factors, especially considering most children at all ages only had one factor, would mean significantly lower preventive care expenditures compared to population-wide strategies. Nine-year-olds could potentially be primary targets (presenting with five risk factors), and secondary those seven-years-old (Figure 4). Both these and earlier findings warrant further research on early signs of CMDs among child populations.

Norway was, according to a 2015 OECD report, the third largest spender per capita on health expenditures and resources among OECD countries, behind USA in first place and Switzerland on second (OECD, 2015). The equivalent 2017 report places Norway in fourth place at USD 6647 in total spending per capita (OECD, 2017). Interestingly, growth of Norwegian prevention expenditure has steadily decreased the past decade (Gmeinder, Morgan, & Mueller, 2017). Annual growth in prevention expenditure per capita was 11.5% from 2007-2009 and at 3.2% from 2013-2015. Preventive care amounted to only 3% (2017) of total Norwegian health expenditures (Figure 7) (Gmeinder et al., 2017; “Health accounts,” 2018).

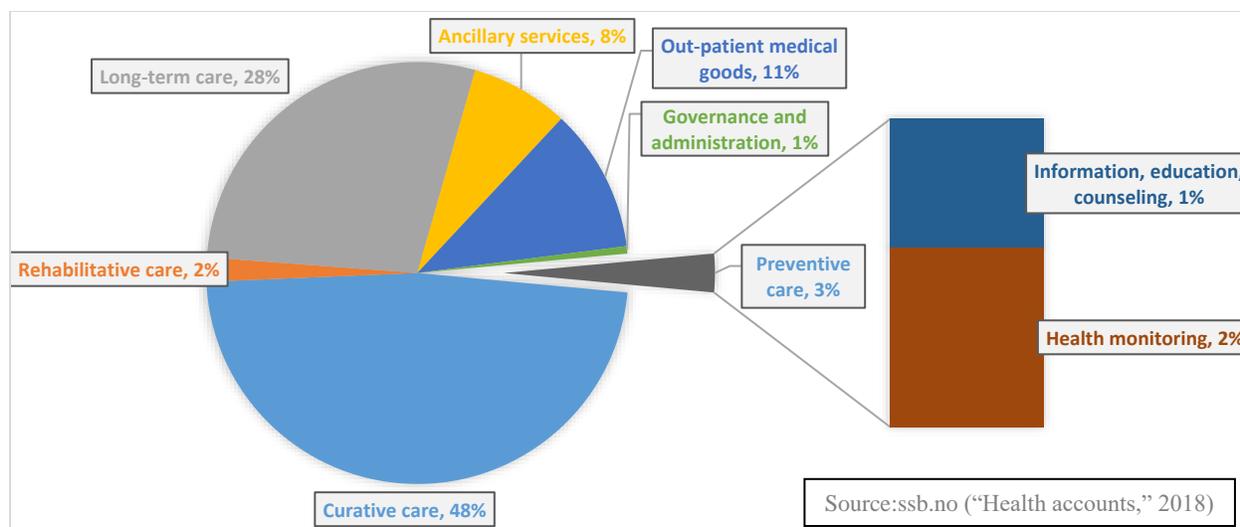


Figure 7: Health expenditure (%) by function of care, 2017

Higher health expenditures are not always indicative of better access or quality of care.

Improving the current health care system lies not in increasing health care investments but rather in reallocation and improving the effectiveness of existing resources. Targeted disease prevention strategies is one such measure that may lead to lowering future hospital admission rates in conjunction with raising economic productivity (Kenkel & Sindelar, 2011). It is important to identify two factors: the rate-limiting steps and the key actors to target (Bauman & Nutbeam, 2013; Schiavo, 2013). That is, addressing the most important constraints for effective health services, and defining the primary and secondary audiences for policy changes.

This paper investigated whether and which children should be targets for primary disease prevention strategies. If so, identifying their primary and secondary audiences would be the reasonable next step. Potential primary audiences being their primary caregivers, teachers, or even the children themselves' influence on their caregivers, and potential secondary audiences being their access to resources/their environment, schools as an arena, friends, or sports facilities (Schiavo, 2013).

#### 4.2.2. *The preventive paradox*

Disease as a continuum of symptoms necessitates population-wide preventive strategies wherever risk is diffused through the whole population (Rose, 1985). This may at first glance

somewhat invalidate the methodology in this thesis. Uncovering whether there is a clustering of risk factors at any level may hold little value in a public health perspective. It is unclear whether targeting those in the high-risk groups at four or more risk factors is cost-effective in reducing the disease burden of CMDs.

Medical practice and public health strategies are often concerned with the segment of health that concerns disease. While this statement may seem self-explanatory, further investigation reveals a dichotomous assumption on disease occurrence. Doctors categorize individuals as healthy or sick and politicians concern themselves with definable in-risk segments of the population. The overall goal is clear: a wish to categorically reduce the number of sick individuals. Rose et al. however argues that these *high-risk strategies*, where efforts are focused on those judged most likely to develop disease, neglects a continuum of disease severity (Rose, Khaw, & Marmot, 2008). This can create a paradoxical situation where, despite sufficient preventive strategies to reduce the number of high-risk individuals, total number of individuals requiring medical care continues to rise.

The argument is that disease concerns, by statistical definition, only a minority of the population. A bell curve dictates that the majority population is “normal” and should traditionally be left to themselves. However, cancer for example is the end-stage of a series of common changes, starting from minor cellular mutations, to premalignant stages, to localized malignancy, to a locally invasive disease, and finally in some cases to systemic invasions (Rose et al., 2008). Coronary heart disease is the same, it involves the gradual narrowing of small vessels that oxygenate the heart through atherogenesis, caused by, among others, the accumulation of serum LDL-C (Mahan, Escott-Stump, Raymond, & Krause, 2012). Both these cases illustrate disease (where their risk factors are continuous distributions) as a continuum or process rather than a dichotomous definition. The practical necessity of clear disease definitions is undisputable: when should an individual be sent home from the hospital, who should receive medication, should there be containment measures for potential epidemic outbreaks, etc. If disease exists in a continuum however, then we can surmise that the majority of those deemed “normal” is potentially at some stage of “disease” even without any clinical diagnosis. Some of these may also require medical care. Even if those in the “normal” group have a lower probability of becoming sick, having a much larger N also means there likely will be a larger number who will

become diseased in this group ( $p \cdot N$ ) than those who are defined in the marginalized in-risk group.

The solution to this issue is then to utilize the analytical method of this thesis as a gradation of disease risk. Disease prevention strategies should be redefined as risk reduction strategies. This allows for multiple targeted measures based on severity of risk for CMDs. Rather than looking for clustering of risk factors, the provided z-scores would be of greater interest (Table 6).

Tailored measures graded by standard deviations from a population average provides a more nuanced and targeted approach to *population-wide* health care systems. Population-specific research is necessary to facilitate this, in order to reveal the population-distribution of specific risk factors. The approach solves the issue of ambiguous definitions for disease when finding target-groups for public health strategies. A quote from Rose et al. summarizes benefits of this strategy perfectly: “A large number of people exposed to a small risk may generate many more cases than a small number exposed to a high risk.” (Rose et al., 2008).

#### **4.1. Dietary diversity and CMD risk**

Exploratory analyses by DDS showed that those with four and five risk factors also had a DDS of three or four. Most of those with zero or one risk factor had a DDS of three. Higher DDS should normally indicate diets that are more varied. These findings could however illustrate that those with a DDS of four may include individuals with higher caloric consumption than necessary. The CMD risk score may, in other words, indicate that those with a higher risk score should be more cautious about a high DDS.

Satisfying dietary recommendations for three of “vegetables, fruits and berries, wholegrain bread, and fish” may be the most cost efficient on a population-scale. Focusing on overall diet patterns, rather than isolated nutrients for cardiometabolic risk may, in fact, be better (Mozaffarian, 2016). Intervening on dietary patterns permit greater flexibility and personal preferences in diet choices. Smaller changes across all these food categories, without overt focus on fulfilling all recommendations, potentially increase compliance and effectiveness of measures.

## 4.2. Ethical considerations

### 4.2.1. *Formal legal responsibilities*

Informed consent was collected from the children's legal guardians in accordance with the Health and Rights Act (Pasient- og brukerrettighetsloven, 1999, §§ 4–4). Consents may be withdrawn at any time and all personal health data can be requested deleted within 30 days as outlined in The Health Research Act (Helseforskningsloven, 2008, § 16). All processing of personal health data is furthermore in accordance with the Health and Rights Act (Helseforskningsloven, 2008, Chapters 7 & 8). All collected data was directly linked to the research aims and participants have a right to access their own personal data upon request.

The Regional Committees for Medical and Health Research Ethics (REK) granted prior approval according to The Health Research Act (Helseforskningsloven, 2008, § 9 §10). The committee is responsible for ensuring that medical and health research in Norway is ethically acceptable. All substantial changes to the project description would be subject to REK's approval in line with The Health Research Act (Helseforskningsloven, 2008, § 11).

### 4.2.2. *Children as a sensitive target group*

School meetings provided parents and guardians opportunities for feedback. As an example, all anthropometric measures and body composition data was kept unavailable for the children themselves as a request from their caregivers. This was to prevent the children from comparing and discussing their measurements between themselves.

There was however a methodological challenge in this. It was possible to cover the body composition scanner's screen while measuring, to train the HOPP-team not to orally convey results to the children, and to note results out of sight before handing their folder back. Secrecy was however heavily reliant on the individual child's obedience to instructions of not looking in their own folder while moving between measurement stations. This was easier among the youngest children in the study sample than the older, where non-compliance to the instruction was more common.

To remedy this, as part of a process to both improve efficiency and lower resource demands, digitizing the data collection could solve multiple challenges. Registering results on for example

synchronized tablet devices at each station would keep them permanently out of reach for the children. Only an ID would be necessary to match measures. It would moreover eliminate time and human resources required in digitizing all paper-based-data, improve security if managed properly (ie. encryption of tablets), and perhaps most interestingly is the possibility of live analytics and error-detection. That is, missing data or errors in data-collection could be discovered on-site and immediately rectified. A simpler variant involving only data collection was implemented as of 2018.

#### *4.2.3. Coding, de-identification, anonymity, and security*

All children were given identifying numbers (IDs) based on class rosters kept secure separately. The data is therefore coded, not de-identified or anonymized (Rothstein, 2010; Sariyar & Schlünder, 2016). The data will be de-identified by June, 2025, at which point all rosters linking IDs with names will be destroyed (“REK,” 2017). Due to the nature of collecting such comprehensive personal measures, there is always a deductive and identity disclosure risk (Sariyar & Schlünder, 2016). That is, given enough motivation and effort, it is possible to link sets of personal characteristics in the dataset to individuals.

Remedying the challenge of not being able to ensure complete anonymity involves improving storage and management solutions. The European Union's (EUs) general data protection regulation (GDPR) came into effect 25th, May 2018. This divides the addressing of data security in two parts: pre- and post-GDPR.

Data security in HOPP falls under two considerations: data storage and data management. The baseline data of which this paper draws its results were stored on a secure network assisted storage (NAS) solution. A Western Digital My Cloud server stored all the coded raw data (“WD corp.,” 2018). Periodic backups were manually executed when necessary. Rosters linking IDs with names were kept separately in a locked room and archive. As for management, the server could be reached with the correct address, username, and password. Physical paper-journals with raw data was additionally stored behind locked doors in locked archives. Only HOPP research-team members were given direct access to the server and selective parts were shared upon request to the project leader for specific purposes (eg. master's thesis work).

The weakest link in data management was therefore the shared data outside of the research team. There were no specific requirements placed on these, neither encryption nor password protection. These were however more likely anonymized by virtue of only a small section of data and variables made available, lowering the risk of deductive disclosure risks.

#### *4.2.4. EU General Data Protection Regulations*

Following the advent of the GDPR however, stricter measures had to be put in place as of May 2018 (University of Oxford, 2018). What entails good research practice is already in line with most GDPR requirements. Most responsibilities following the GDPR are fulfilled through the registration of the project under REK. These include, but are not limited to, the fair use and transparency of personal data, a legitimate and clear purpose for the data collection, collection of only relevant information, and de-identification of the data. These are already satisfied through the project description submitted to the ethics committee detailing the project-aim, target population, informed consent, allowances for opting out, and procedures for the de-identification of the data (“REK,” 2017). Publication of study-results in reputed scientific journals ensures additionally fair use and transparency. Areas where the new regulations require action are the stricter requirements on storage security and management.

The clauses involving data security are to prevent unauthorized, unlawful access and use of personal data. That includes unsolicited and accidental loss and destruction of the data. In short this affects the HOPP-data on three fronts; (a) ensuring formal authorization of access to data, (b) clearly defined purposes for each person given access, and (c) damage control in case the data ends up in unauthorized hands. The result of the first two points was to move the data offline from the NAS to offline hard disks with 256-bit AES volume-encryption and the purchase of pin protected encrypted memory sticks for secure data transfers. All of which was stored in locked archives and rooms where only authorized individuals had access. Placing both physical and digital barriers makes it easier to limit access only to those with specific need. It also lowers risk of unauthorized access. Data encryption furthermore protects the personal data in case of accidental loss or theft (whether digital or physical).

Moving the data offline and requiring physical transfers through authorized encrypted memory sticks does however place some limitations on efficiency. A cloud-based solution would allow

unhindered access to always-updated data, enabling collaboration that is more efficient as well as lowering human resource demands. The HOPP-research solutions are, however, sufficient as intermediary solutions in the advent of the new EU regulations. There are several technical and administrative challenges that must be addressed for secure cloud-based solutions of research data. While there are third party providers offering secure storage solutions for researchers (e.g. National e-Infrastructure for Research Data and the Norwegian Centre for Research Data), a challenge would be the protection of intellectual property. These services often place a number of requirements on the type of data stored, publication and near-unsolicited access to the data, or charge a sizeable premium. Larger institutions would therefore benefit from setting up comprehensive in-house solutions. That is, secure cloud-based storage systems, mechanisms for authorization of data access, and either secure dedicated computers or software for protecting downloaded research data on personal workstations.

### **4.3. Major strengths, limitations, and future research**

#### *4.3.1. Major strengths*

Major strengths of this study include the large sample size evenly distributed by age and sex, and the use of biomarkers. The effect of respondents' discrimination capability and literacy levels were as such reduced in the present study (Johnson & Morgan, 2016). The exclusion of PA level data (by accelerometers) is an example of favoring biomarkers. PA level introduces many confounding behavioral traits, as it is not purely a physiological measurement.

Few previous studies have collected similarly comprehensive data in Norway for this age range and among a mostly healthy child population. Most studies include specific ages with smaller sample sizes (L. B. Andersen et al., 2003; Bugge et al., 2013; Chu, Rimm, Wang, Liou, & Shieh, 1998; Dalene et al., 2017; Steene-Johannessen et al., 2009, 2009). The sample size enables both age and sex specific quartile divisions (Table 4). This strength is paradoxically also one of the major limitations of the study; quartile divisions and z-scores are population-specific. With the method used in this thesis, the sample averages and distributions become defining of subsequent risk score analyses. Quartile cut-offs (Table 5), z-scores (Table 6), and clustering of CMD risk factors (Figure 5) provide, however, a piece of the puzzle in conjunction with other studies. The study-results may be limited to six to twelve-year-olds in eastern-Norway, if not specifically to

Horten municipality and Akershus County. The HOPP-sample has, for example, a higher proportion of high parental education levels compared to the rest of the country (Deng & Fredriksen, 2018). z-Scores are in such cases the most relevant for study comparisons.

Providing data on the distribution of the continuous CMD risk score is another strength of the study, and is important to the implementation of effective preventive strategies. Rather than a simple dichotomization of CMD risk such as the MetS diagnosis based on arbitrary cutoffs, a CMD score better reflects the gradual and continuous nature of lifestyle diseases such as CMDs. The continuous score is particularly useful in a research perspective as it allows exploring the relative impact of distinct CMD risk levels in various populations.

#### *4.3.2. Major limitations*

As discussed in the article, a clear limitation of the study is the lack of a clinical outcome. Even without a clear clinical outcome, short-term prospective study designs would enable the assessment of changes in the risk scores. The only consolation this thesis relies on is that all included individual variables of the CMD risk score are known risk factors and track from childhood to adolescence and adulthood (Ali et al., 2014; Lars Bo Andersen et al., 2004; Barstad et al., 2018; Bugge et al., 2013; van Vliet et al., 2011).

This thesis does, moreover, not perform any validity or reliability analyses for the CMD risk construct. Tests of internal consistency would reveal the construct's reliability. There are however some issues with either principal factor analysis or tests for internal consistency. First is the question of how to treat inverted variables such as the Andersen aerobic fitness test. Cronbach's alpha, as an example, is normally best at dealing with e.g. likert scales that are easily inverted. Second is that the choice of variables become subject to statistical methods and less on previous research and ease of access for clinicians. This is especially an issue considering that defining CMDs may differ at different life-stages, in different ethnic groups, and vary by SES. In contrast, the current cluster score manages to include all major risk categories (adiposity, blood lipids, metabolic factors, hemodynamic measures, and physical fitness) while minimizing multicollinearity.

#### **4.4. Final remarks**

CMD risk may increase with increasing age based on secular trends among Norwegian children aged 6-12 years from the HOPP baseline. Some of the concern may however be mitigated by a lack of significant clustering of risk factors in this particular age group. While these are important findings, this thesis' real value lies in its utilization and presentation of a continuous CMD risk score. Recognizing that disease prevention for a majority of the population is a matter of *risk reduction* enables stratified prevention measures by degree of risk.

In light of the negative global trends in physical health, the lack of a consensus definition for CMD risk for children necessitates longitudinal cohort studies. These would allow for studying longitudinal and secular trends as well as validity testing constructs of CMD risk. Future research on CMD risk scores should split analyses by sex, age groups, ethnicities, and SES.

## 5. Bibliography

- Aadland, E., Andersen, L. B., Lerum, Ø., & Resaland, G. K. (2017). The Andersen aerobic fitness test: New peak oxygen consumption prediction equations in 10 and 16-year olds. *Scandinavian Journal of Medicine & Science in Sports*, n/a-n/a. <https://doi.org/10.1111/sms.12985>
- Aadland, E., Andersen, L. B., Skrede, T., Ekelund, U., Anderssen, S. A., & Resaland, G. K. (2017). Reproducibility of objectively measured physical activity and sedentary time over two seasons in children; Comparing a day-by-day and a week-by-week approach. *PLOS ONE*, 12(12), e0189304. <https://doi.org/10.1371/journal.pone.0189304>
- Aadland, E., Terum, T., Mamen, A., Andersen, L. B., & Resaland, G. K. (2014). The Andersen Aerobic Fitness Test: Reliability and Validity in 10-Year-Old Children. *PLoS ONE*, 9(10). <https://doi.org/10.1371/journal.pone.0110492>
- Abarca-Gómez, L., Abdeen, Z. A., Hamid, Z. A., Abu-Rmeileh, N. M., Acosta-Cazares, B., Acuin, C., ... Ezzati, M. (2017). Worldwide trends in body-mass index, underweight, overweight, and obesity from 1975 to 2016: a pooled analysis of 2416 population-based measurement studies in 128·9 million children, adolescents, and adults. *The Lancet*, 0(0). [https://doi.org/10.1016/S0140-6736\(17\)32129-3](https://doi.org/10.1016/S0140-6736(17)32129-3)
- Ahrens, W., Moreno, L. A., Mårild, S., Molnár, D., Siani, A., Henauw, S. D., ... Pigeot, I. (2014). Metabolic syndrome in young children: definitions and results of the IDEFICS study. *International Journal of Obesity*, 38(S2), S4. <https://doi.org/10.1038/ijo.2014.130>
- Ajala, O., Mold, F., Boughton, C., Cooke, D., & Whyte, M. (2017). Childhood predictors of cardiovascular disease in adulthood. A systematic review and meta-analysis. *Obesity Reviews*, 18(9), 1061–1070. <https://doi.org/10.1111/obr.12561>

- Ali, O., Cerjak, D., Kent, J. W., James, R., Blangero, J., & Zhang, Y. (2014). Obesity, central adiposity and cardiometabolic risk factors in children and adolescents: a family-based study. *Pediatric Obesity*, *9*(3), e58–e62. <https://doi.org/10.1111/j.2047-6310.2014.218.x>
- Andersen, L. B., Andersen, T. E., Andersen, E., & Anderssen, S. A. (2008). An intermittent running test to estimate maximal oxygen uptake: the Andersen test. *The Journal of Sports Medicine and Physical Fitness*, *48*(4), 434–437.
- Andersen, L. B., Wedderkopp, N., Hansen, H. S., Cooper, A. R., & Froberg, K. (2003). Biological cardiovascular risk factors cluster in Danish children and adolescents: the European Youth Heart Study. *Preventive Medicine*, *37*(4), 363–367. [https://doi.org/10.1016/S0091-7435\(03\)00145-2](https://doi.org/10.1016/S0091-7435(03)00145-2)
- Andersen, Lars Bo, Hasselstrøm, H., Grønfeltdt, V., Hansen, S. E., & Karsten, F. (2004). The relationship between physical fitness and clustered risk, and tracking of clustered risk from adolescence to young adulthood: eight years follow-up in the Danish Youth and Sport Study. *The International Journal of Behavioral Nutrition and Physical Activity*, *1*(1), 6. <https://doi.org/10.1186/1479-5868-1-6>
- Andersen, Lars Bo, Lauersen, J. B., Brønd, J. C., Anderssen, S. A., Sardinha, L. B., Steene-Johannessen, J., ... Ekelund, U. (2015). A New Approach to Define and Diagnose Cardiometabolic Disorder in Children. *Journal of Diabetes Research*, 2015. Retrieved from <https://doaj.org>
- Anderson, L. N., Lebovic, G., Hamilton, J., Hanley, A. J., McCrindle, B. W., Maguire, J. L., ... Birken, C. S. (2016). Body Mass Index, Waist Circumference, and the Clustering of Cardiometabolic Risk Factors in Early Childhood. *Paediatric and Perinatal Epidemiology*, *30*(2), 160–170. <https://doi.org/10.1111/ppe.12268>

- Ashwell, M., Gunn, P., & Gibson, S. (2012). Waist-to-height ratio is a better screening tool than waist circumference and BMI for adult cardiometabolic risk factors: systematic review and meta-analysis. *Obesity Reviews*, *13*(3), 275–286. <https://doi.org/10.1111/j.1467-789X.2011.00952.x>
- ATP III At-A-Glance. (2001). Retrieved October 24, 2018, from <https://www.nhlbi.nih.gov/health-topics/all-publications-and-resources/atp-iii-glance-quick-desk-reference>
- Barstad, L. H., Júlíusson, P. B., Johnson, L. K., Hertel, J. K., Lekhal, S., & Hjelmæsæth, J. (2018). Gender-related differences in cardiometabolic risk factors and lifestyle behaviors in treatment-seeking adolescents with severe obesity. *BMC Pediatrics*, *18*. <https://doi.org/10.1186/s12887-018-1057-3>
- Bauman, A. E., & Nutbeam, D. (2013). *Evaluation in a Nutshell: A Practical Guide to the Evaluation of Health Promotion Programs*. McGraw-Hill.
- Berenson, G. S., Srinivasan, S. R., & Nicklas, T. A. (1998). Atherosclerosis: a nutritional disease of childhood. *The American Journal of Cardiology*, *82*(10, Supplement 2), 22–29. [https://doi.org/10.1016/S0002-9149\(98\)00719-X](https://doi.org/10.1016/S0002-9149(98)00719-X)
- Berenson, G. S., Srinivasan, S. R., Xu, J. H., & Chen, W. (2016). Adiposity and Cardiovascular Risk Factor Variables in Childhood Are Associated With Premature Death From Coronary Heart Disease in Adults: The Bogalusa Heart Study. *The American Journal of the Medical Sciences*, *352*(5), 448–454. <https://doi.org/10.1016/j.amjms.2016.08.006>
- Bleich, S. N., Vercammen, K. A., Zatz, L. Y., Frelief, J. M., Ebbeling, C. B., & Peeters, A. (2017). Interventions to prevent global childhood overweight and obesity: a systematic

- review. *The Lancet Diabetes & Endocrinology*, 0(0). [https://doi.org/10.1016/S2213-8587\(17\)30358-3](https://doi.org/10.1016/S2213-8587(17)30358-3)
- Brouwer, S. I., Stolk, R. P., Liem, E. T., Lemmink, K. A. P. M., & Corpeleijn, E. (2013). The role of fitness in the association between fatness and cardiometabolic risk from childhood to adolescence. *Pediatric Diabetes*, 14(1), 57–65. <https://doi.org/10.1111/j.1399-5448.2012.00893.x>
- Bugge, A., El-Naaman, B., McMurray, R. G., Froberg, K., & Andersen, L. B. (2013). Tracking of clustered cardiovascular disease risk factors from childhood to adolescence. *Pediatric Research*, 73(2), 245–249. <https://doi.org/10.1038/pr.2012.158>
- Chen, X., & Wang, Y. (2008). Tracking of blood pressure from childhood to adulthood: A systematic review and meta-regression analysis. *Circulation*, 117(25), 3171–3180. <https://doi.org/10.1161/CIRCULATIONAHA.107.730366>
- Chiu, S., Bergeron, N., Williams, P. T., Bray, G. A., Sutherland, B., & Krauss, R. M. (2016). Comparison of the DASH (Dietary Approaches to Stop Hypertension) diet and a higher-fat DASH diet on blood pressure and lipids and lipoproteins: a randomized controlled trial. *The American Journal of Clinical Nutrition*, 103(2), 341–347. <https://doi.org/10.3945/ajcn.115.123281>
- Chu, N. F., Rimm, E. B., Wang, D. J., Liou, H. S., & Shieh, S. M. (1998). Clustering of cardiovascular disease risk factors among obese schoolchildren: the Taipei Children Heart Study. *The American Journal of Clinical Nutrition*, 67(6), 1141–1146.
- Chung, I. H., Park, S., Park, M. J., & Yoo, E.-G. (2016). Waist-to-Height Ratio as an Index for Cardiometabolic Risk in Adolescents: Results from the 1998-2008 KNHANES. *Yonsei Medical Journal*, 57(3), 658–663. <https://doi.org/10.3349/ymj.2016.57.3.658>

- Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences* (2 edition). Hillsdale, N.J: Routledge.
- Cole, T. J., & Lobstein, T. (2012). Extended international (IOTF) body mass index cut-offs for thinness, overweight and obesity. *Pediatric Obesity*, 7(4), 284–294.  
<https://doi.org/10.1111/j.2047-6310.2012.00064.x>
- Cole, Tim J., Bellizzi, M. C., Flegal, K. M., & Dietz, W. H. (2000). Establishing a standard definition for child overweight and obesity worldwide: international survey. *BMJ*, 320(7244), 1240. <https://doi.org/10.1136/bmj.320.7244.1240>
- Conexus Insight (formerly PULS). (2018). Retrieved August 18, 2017, from <http://conexus.net/nb/insight/>
- Conklin, A. I., Monsivais, P., Khaw, K.-T., Wareham, N. J., & Forouhi, N. G. (2016). Dietary Diversity, Diet Cost, and Incidence of Type 2 Diabetes in the United Kingdom: A Prospective Cohort Study. *PLOS Medicine*, 13(7), e1002085.  
<https://doi.org/10.1371/journal.pmed.1002085>
- da Silva, C. F., Burgos, M. S., da Silva, P. T., Burgos, L. T., Welser, L., Sehn, A. P., ... Reuter, C. P. (2017). Relationship between Cardiometabolic Parameters and Elevated Resting and Effort Heart Rate in Schoolchildren. *Arquivos Brasileiros de Cardiologia*, 109(3), 191–198. <https://doi.org/10.5935/abc.20170103>
- Dalene, K. E., Anderssen, S. A., Andersen, L. B., Steene-Johannessen, J., Ekelund, U., Hansen, B. H., & Kolle, E. (2017). Cross-sectional and prospective associations between physical activity, body mass index and waist circumference in children and adolescents. *Obesity Science & Practice*, 3(3), 249–257. <https://doi.org/10.1002/osp4.114>

- Deng, W. H., & Fredriksen, P. M. (2018). Objectively assessed moderate-to-vigorous physical activity levels among primary school children in Norway: The Health Oriented Pedagogical Project (HOPP). *Scandinavian Journal of Public Health*, 46(21\_suppl), 38–47. <https://doi.org/10.1177/1403494818771207>
- Farhangi, M. A., & Jahangiry, L. (2018). Dietary diversity score is associated with cardiovascular risk factors and serum adiponectin concentrations in patients with metabolic syndrome. *BMC Cardiovascular Disorders*, 18(1), 68. <https://doi.org/10.1186/s12872-018-0807-3>
- Folkehelseinstituttet. (2016, April 12). Høyt blodtrykk - fakta om hypertensjon - FHI. Retrieved May 26, 2016, from <http://www.fhi.no/artikler/?id=42975>
- Forouzanfar, M. H., Afshin, A., Alexander, L. T., Anderson, H. R., Bhutta, Z. A., Biryukov, S., ... Murray, C. J. L. (2016). Global, regional, and national comparative risk assessment of 79 behavioural, environmental and occupational, and metabolic risks or clusters of risks, 1990–2015: a systematic analysis for the Global Burden of Disease Study 2015. *The Lancet*, 388(10053), 1659–1724. [https://doi.org/10.1016/S0140-6736\(16\)31679-8](https://doi.org/10.1016/S0140-6736(16)31679-8)
- Fredriksen, P. M., Hjelle, O. P., Mamen, A., Meza, T. J., & Westerberg, A. C. (2017). The health Oriented pedagogical project (HOPP) - a controlled longitudinal school-based physical activity intervention program. *BMC Public Health*, 17, 370. <https://doi.org/10.1186/s12889-017-4282-z>
- Gakidou, E., Afshin, A., Abajobir, A. A., Abate, K. H., Abbafati, C., Abbas, K. M., ... Murray, C. J. L. (2017). Global, regional, and national comparative risk assessment of 84 behavioural, environmental and occupational, and metabolic risks or clusters of risks,

- 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. *The Lancet*, 390(10100), 1345–1422. [https://doi.org/10.1016/S0140-6736\(17\)32366-8](https://doi.org/10.1016/S0140-6736(17)32366-8)
- Gmeinder, M., Morgan, D., & Mueller, M. (2017). How much do OECD countries spend on prevention? <https://doi.org/10.1787/f19e803c-en>
- Goodman, E., Daniels, S. R., Meigs, J. B., & Dolan, L. M. (2007). Instability in the diagnosis of metabolic syndrome in adolescents. *Circulation*, 115(17), 2316–2322. <https://doi.org/10.1161/CIRCULATIONAHA.106.669994>
- Hansen, L. B., Myhre, J. B., Johansen, A. M. W., Paulsen, M. M., & Andersen, L. F. (2016). *Ungkost 3 - Landsomfattende kostholdsundersøkelse blant elever i 4. -og 8. klasse i Norge, 2015*. (Rapport) (p. 92). Oslo: Folkehelseinstituttet.
- Health expenditure, by function of care (NOK million) 2011 - 2017. (2018, March 14). [Statistics]. Retrieved October 17, 2018, from <https://www.ssb.no/en/statbank/table/10814>
- Helsedirektoratet. (2009a). *Nasjonal faglig retningslinje for individuell primærforebygging av hjerte- og karsykdommer* (Nasjonale faglige retningslinjer No. IS-1550) (p. 135). Oslo.
- Helsedirektoratet. (2009b). *Nasjonale faglige retningslinjer: Diabetes: Forebygging, diagnostikk og behandling* (Nasjonale faglige retningslinjer No. IS-1674) (p. 147). Oslo.
- Helsedirektoratet. (2010). *Nasjonal faglig retningslinje for veiing og måling i helsestasjons og skolehelsetjenesten* (Nasjonale faglige retningslinjer No. IS-1736) (p. 49). Oslo.
- Helsedirektoratet. (2011). *Kostråd for å fremme folkehelsen og forebygge kroniske sykdommer – Metodologi og vitenskapelig kunnskapsgrunnlag* (Rapport No. IS-1881) (p. 353). Oslo.
- Helseforskningsloven. (2008). *Lov om medisinsk og helsefaglig forskning* (LOV-2008-06-20-44). Retrieved from <https://lovdata.no/dokument/NL/lov/2008-06-20-44>

- Huang, P. L. (2009). A comprehensive definition for metabolic syndrome. *Disease Models & Mechanisms*, 2(5–6), 231–237. <https://doi.org/10.1242/dmm.001180>
- Hui, W. S., Liu, Z., & Ho, S. C. (2010). Metabolic syndrome and all-cause mortality: a meta-analysis of prospective cohort studies. *European Journal of Epidemiology*, 25(6), 375–384. <https://doi.org/10.1007/s10654-010-9459-z>
- Jackson, S. L., Yang, E. C., & Zhang, Z. (2018). Income Disparities and Cardiovascular Risk Factors Among Adolescents. *Pediatrics*, e20181089. <https://doi.org/10.1542/peds.2018-1089>
- Jacobson, T. A., Ito, M. K., Maki, K. C., Orringer, C. E., Bays, H. E., Jones, P. H., ... Brown, W. V. (2015). National Lipid Association Recommendations for Patient-Centered Management of Dyslipidemia: Part 1—Full Report. *Journal of Clinical Lipidology*, 9(2), 129–169. <https://doi.org/10.1016/j.jacl.2015.02.003>
- Jayawardene, W. P., Lohrmann, D., Dickinson, S., Talagala, S., & Torabi, M. (2017). Clinical measures of obesity and cumulative cardiometabolic risk in adolescents. *Clinical Obesity*, 7(1), 11–21. <https://doi.org/10.1111/cob.12171>
- Johnson, R. L., & Morgan, G. B. (2016). *Survey Scales: A Guide to Development, Analysis, and Reporting* (1 edition). New York: The Guilford Press.
- Júlíusson, P. B., Eide, G. E., Roelants, M., Waaler, P. E., Hauspie, R., & Bjerknes, R. (2010). Overweight and obesity in Norwegian children: prevalence and socio-demographic risk factors. *Acta Pædiatrica*, 99(6), 900–905. <https://doi.org/10.1111/j.1651-2227.2010.01730.x>

- Kamel, M., Smith, B. T., Wahi, G., Carsley, S., Birken, C. S., & Anderson, L. N. (2018). Continuous cardiometabolic risk score definitions in early childhood: a scoping review. *Obesity Reviews*, 0(0). <https://doi.org/10.1111/obr.12748>
- Kelly, A. S., Steinberger, J., Jacobs, D. R., Hong, C.-P., Moran, A., & Sinaiko, A. R. (2011). Predicting Cardiovascular Risk in Young Adulthood from Metabolic Syndrome, its Component Risk Factors, and a Cluster Score in Childhood. *International Journal of Pediatric Obesity : IJPO : An Official Journal of the International Association for the Study of Obesity*, 6(0), e283–e289. <https://doi.org/10.3109/17477166.2010.528765>
- Kenkel, D. S., & Sindelar, J. (2011). Economics of Health Behaviors and Addictions: Contemporary Issues and Policy Implications. *The Oxford Handbook of Health Economics*. <https://doi.org/10.1093/oxfordhb/9780199238828.013.0010>
- Kjøllestad, M. K. R., Hjellset, V. T., Bjørge, B., Holmboe-Ottesen, G., & Wandel, M. (2011). Perceptions of risk factors for diabetes among Norwegian-Pakistani women participating in a culturally adapted intervention. *Ethnicity & Health*, 16(3), 279–297. <https://doi.org/10.1080/13557858.2011.573537>
- Koskinen, J., Juonala, M., Dwyer, T., Venn, A., Thomson, R., Bazzano, L., ... Magnussen, C. G. (2017). Impact of Lipid Measurements in Youth in Addition to Conventional Clinic-Based Risk Factors on Predicting Preclinical Atherosclerosis in Adulthood: The International Childhood Cardiovascular Cohort (i3C) Consortium. *Circulation*, CIRCULATIONAHA.117.029726. <https://doi.org/10.1161/CIRCULATIONAHA.117.029726>
- Lachat, C., Hawwash, D., Ocké, M. C., Berg, C., Forsum, E., Hörnell, A., ... Huybrechts, I. (2016). Strengthening the Reporting of Observational Studies in Epidemiology—

- Nutritional Epidemiology (STROBE-nut): An Extension of the STROBE Statement. *PLOS Medicine*, *13*(6), e1002036. <https://doi.org/10.1371/journal.pmed.1002036>
- Lemieux, I., Lamarche, B., Couillard, C., Pascot, A., Cantin, B., Bergeron, J., ... Després, J.-P. (2001). Total Cholesterol/HDL Cholesterol Ratio vs LDL Cholesterol/HDL Cholesterol Ratio as Indices of Ischemic Heart Disease Risk in Men: The Quebec Cardiovascular Study. *Archives of Internal Medicine*, *161*(22), 2685–2692. <https://doi.org/10.1001/archinte.161.22.2685>
- Li, L., Pérez, A., Wu, L.-T., Ranjit, N., Brown, H. S., & Kelder, S. H. (2016). Cardiometabolic Risk Factors among Severely Obese Children and Adolescents in the United States, 1999–2012. *Childhood Obesity*, *12*(1), 12–19. <https://doi.org/10.1089/chi.2015.0136>
- Llewellyn, A., Simmonds, M., Owen, C. G., & Woolacott, N. (2016). Childhood obesity as a predictor of morbidity in adulthood: a systematic review and meta-analysis. *Obesity Reviews*, *17*(1), 56–67. <https://doi.org/10.1111/obr.12316>
- Magge, S. N., Goodman, E., Armstrong, S. C., Nutrition, C. O., Endocrinology, S. O., & Obesity, S. O. (2017). The Metabolic Syndrome in Children and Adolescents: Shifting the Focus to Cardiometabolic Risk Factor Clustering. *Pediatrics*, e20171603. <https://doi.org/10.1542/peds.2017-1603>
- Mahan, L. K., Escott-Stump, S., Raymond, J. L., & Krause, M. V. (Eds.). (2012). *Krause's food & the nutrition care process* (13th ed.). St. Louis, Mo: Elsevier/Saunders.
- Martin, S. S., Blaha, M. J., Elshazly, M. B., Brinton, E. A., Toth, P. P., McEvoy, J. W., ... Jones, S. R. (2013). Friedewald-Estimated Versus Directly Measured Low-Density Lipoprotein Cholesterol and Treatment Implications. *Journal of the American College of Cardiology*, *62*(8), 732–739. <https://doi.org/10.1016/j.jacc.2013.01.079>

- Maumus, S., Marie, B., Siest, G., & Visvikis-Siest, S. (2005). A Prospective Study on the Prevalence of Metabolic Syndrome Among Healthy French Families: Two cardiovascular risk factors (HDL cholesterol and tumor necrosis factor- $\alpha$ ) are revealed in the offspring of parents with metabolic syndrome. *Diabetes Care*, 28(3), 675–682.  
<https://doi.org/10.2337/diacare.28.3.675>
- Mehta, S. K. (2015). Waist Circumference to Height Ratio in Children and Adolescents. *Clinical Pediatrics*, 54(7), 652–658. <https://doi.org/10.1177/0009922814557784>
- Metabolic Syndrome. (2018). Retrieved October 24, 2018, from <https://www.heart.org/en/health-topics/metabolic-syndrome>
- Mozaffarian, D. (2016). Dietary and Policy Priorities for Cardiovascular Disease, Diabetes, and Obesity: A Comprehensive Review. *Circulation*, 133(2), 187–225.  
<https://doi.org/10.1161/CIRCULATIONAHA.115.018585>
- Nasjonal folkehelseinstitutt. (2018). *Helsetilstanden i Norge 2018* (Rapport No. 2018). Oslo.
- OECD. (2015). *Health at a Glance 2015*. OECD Publishing.  
[https://doi.org/10.1787/health\\_glance-2015-en](https://doi.org/10.1787/health_glance-2015-en)
- OECD. (2017). *Health at a Glance 2017: OECD Indicators*. OECD.  
[https://doi.org/10.1787/health\\_glance-2017-en](https://doi.org/10.1787/health_glance-2017-en)
- Otto, M. C. de O., Padhye, N. S., Bertoni, A. G., Jr, D. R. J., & Mozaffarian, D. (2015). Everything in Moderation - Dietary Diversity and Quality, Central Obesity and Risk of Diabetes. *PLOS ONE*, 10(10), e0141341. <https://doi.org/10.1371/journal.pone.0141341>
- Øverby, N. C., & Andersen, L. F. (2002). *Ungkost-2000 - Landsomfattende kostholdsundersøkelse blant elever i 4.-og 8. klasse i Norge* (Rapport No. IS-0447) (p. 40). Oslo: Sosial- og helsedirektoratet, avdeling for ernæring.

Pasient- og brukerrettighetsloven. (1999). *Lov om pasient- og brukerrettigheter* (LOV-1999-07-02-63). Retrieved from <https://lovdata.no/dokument/NL/lov/1999-07-02-63>

Petkeviciene, J., Klumbiene, J., Kriaucioniene, V., Raskiliene, A., Sakyte, E., & Ceponiene, I. (2015). Anthropometric measurements in childhood and prediction of cardiovascular risk factors in adulthood: Kaunas cardiovascular risk cohort study. *BMC Public Health, 15*(1), 218. <https://doi.org/10.1186/s12889-015-1528-5>

REK – Regionale komiteer for medisinsk og helsefaglig forskningsetikk. (2017, January 24). Retrieved January 24, 2017, from [https://helseforskning.etikk.no/page/prosjekterirek/prosjektregister/prosjekt?p\\_document\\_id=538318&p\\_parent\\_id=541723&\\_ikbLanguageCode=us](https://helseforskning.etikk.no/page/prosjekterirek/prosjektregister/prosjekt?p_document_id=538318&p_parent_id=541723&_ikbLanguageCode=us)

Rose, G. (1985). Sick Individuals and Sick Populations. *International Journal of Epidemiology, 14*(1), 32–38. <https://doi.org/10.1093/ije/14.1.32>

Rose, G., Khaw, K.-T., & Marmot, M. (2008). *Rose's Strategy of Preventive Medicine*. Oxford University Press. Retrieved from <http://www.oxfordscholarship.com/view/10.1093/acprof:oso/9780192630971.001.0001/acprof-9780192630971>

Rothstein, M. A. (2010). Is Deidentification Sufficient to Protect Health Privacy in Research? *The American Journal of Bioethics : AJOB, 10*(9), 3–11. <https://doi.org/10.1080/15265161.2010.494215>

Sariyar, M., & Schlünder, I. (2016). Reconsidering Anonymization-Related Concepts and the Term “Identification” Against the Backdrop of the European Legal Framework. *Biopreservation and Biobanking, 14*(5), 367–374. <https://doi.org/10.1089/bio.2015.0100>

- Schiavo, R. (2013). *Health Communication: From Theory to Practice* (2 edition). San Francisco: Jossey-Bass.
- Selmer, R., Iglund, J., Ariansen, I., Tverdal, A., Njølstad, I., Furu, K., ... Klemsdal, T. O. (2017). NORRISK 2: A Norwegian risk model for acute cerebral stroke and myocardial infarction. *European Journal of Preventive Cardiology*, *24*(7), 773–782.  
<https://doi.org/10.1177/2047487317693949>
- Simmonds, M., Llewellyn, A., Owen, C. G., & Woolacott, N. (2016). Predicting adult obesity from childhood obesity: a systematic review and meta-analysis. *Obesity Reviews*, *17*(2), 95–107. <https://doi.org/10.1111/obr.12334>
- Steene-Johannessen, J., Kolle, E., Anderssen, S. A., & Andersen, L. B. (2009). Cardiovascular disease risk factors in a population-based sample of Norwegian children and adolescents. *Scandinavian Journal of Clinical and Laboratory Investigation*, *69*(3), 380–386.  
<https://doi.org/10.1080/00365510802691771>
- Stoner, L., Weatherall, M., Skidmore, P., Castro, N., Lark, S., Faulkner, J., & Williams, M. A. (2017). Cardiometabolic Risk Variables in Preadolescent Children: A Factor Analysis. *Journal of the American Heart Association: Cardiovascular and Cerebrovascular Disease*, *6*(10). <https://doi.org/10.1161/JAHA.117.007071>
- Suglia, S. F., Koenen, K. C., Boynton-Jarrett, R., Chan, P. S., Clark, C. J., Danese, A., ... Research, and C. on Q. of C. and O. (2017). Childhood and Adolescent Adversity and Cardiometabolic Outcomes: A Scientific Statement From the American Heart Association. *Circulation*, CIR.0000000000000536.  
<https://doi.org/10.1161/CIR.0000000000000536>

- The GBD 2015 Obesity Collaborators. (2017). Health Effects of Overweight and Obesity in 195 Countries over 25 Years. *New England Journal of Medicine*, 377(1), 13–27.  
<https://doi.org/10.1056/NEJMoa1614362>
- The IDF consensus worldwide definition of the metabolic syndrome. (2015). International Diabetes Federation. Retrieved from <http://www.idf.org/metabolic-syndrome>
- University of Oxford. (2018). Responsibilities under GDPR. Retrieved October 13, 2018, from <https://researchsupport.admin.ox.ac.uk/policy/data/responsibilities#collapse461671>
- van Vliet, M., Heymans, M. W., von Rosenstiel, I. A., Brandjes, D. P., Beijnen, J. H., & Diamant, M. (2011). Cardiometabolic risk variables in overweight and obese children: a worldwide comparison. *Cardiovascular Diabetology*, 10, 106.  
<https://doi.org/10.1186/1475-2840-10-106>
- Wadhera, R. K., Steen, D. L., Khan, I., Giugliano, R. P., & Foody, J. M. (2016). A review of low-density lipoprotein cholesterol, treatment strategies, and its impact on cardiovascular disease morbidity and mortality. *Journal of Clinical Lipidology*, 10(3), 472–489.  
<https://doi.org/10.1016/j.jacl.2015.11.010>
- Wallace, T. M., Levy, J. C., & Matthews, D. R. (2004). Use and Abuse of HOMA Modeling. *Diabetes Care*, 27(6), 1487–1495. <https://doi.org/10.2337/diacare.27.6.1487>
- WD My Cloud. (2018). Retrieved October 13, 2018, from <https://www.wdc.com/products/personal-cloud-storage/my-cloud.html>
- Weisstein, E. W. (2018). Quartile [Text]. Retrieved November 13, 2018, from <http://mathworld.wolfram.com/Quartile.html>
- WHO. (2016, May 24). Global Database on Body Mass Index. Retrieved May 24, 2016, from <http://apps.who.int/bmi/index.jsp>

**Title: Cardiovascular risk factors in a child population – the Health Oriented Pedagogical Project (HOPP)**

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Authors: Deng WH<sup>1,2\*</sup>, Lindberg M<sup>3</sup>, Hjelle OP<sup>2</sup>, Mamen A<sup>2</sup> & Fredriksen PM<sup>2</sup>

<sup>1</sup> *Oslo Metropolitan University – Department of Health Sciences, Oslo, Norway*

<sup>2</sup> *Kristiania University College - Department of Health Sciences, Oslo, Norway*

<sup>3</sup> *Central Laboratory, Vestfold Hospital Trust, Tønsberg, Norway*

*\*Corresponding author, weihaideng@gmail.com*

## **Abstract**

**Aims:** The main aim of the present study was to investigate the clustering of risk factors for cardiovascular diseases and metabolic syndrome in a large, healthy representative Norwegian child population. **Methods:** From a population of 2817, parents of 2297 children agreed to participate. Values of waist circumference (WC), total cholesterol (TC), high density lipoprotein (HDL-C), systolic blood pressure (SBP), haemoglobin-A1c (HbA1c) and Andersen aerobic fitness test were used to test clustering of cardiometabolic risk factors in this sample. Expected distribution of probability from 0-5 risk factors was accordingly: 23.7%, 39.6%, 26.4%, 8.8%, 1.5%, and 0.1%. A cardiometabolic risk score from zero to five for each individual was derived by adding the number of variables in the least desirable quartile (highest for WC, SBP, TC, and HbA1c; lowest for aerobic fitness and HDL-C). **Results:** A risk ratio of 5.8 (95% confidence interval 0.7-46.9) was found at five risk factors, though the small sample size rendered results non-significant. An explorative analysis combining children with four and five risk factors does not reveal any significant clustering either. **Conclusion:** No clustering of risk factors was found among Norwegian children aged 6-12-years.

## Background

There has been a considerable increase in the prevalence of obesity the last decades. Almost a third of the adult population in the world are obese (607 million) (The GBD 2015 Obesity Collaborators, 2017). As a result, the worldwide burden of cardiovascular and metabolic diseases has increased (The GBD 2015 Obesity Collaborators, 2017). In addition, increased time spent inactive may augment the risks of developing both cardiovascular and metabolic diseases. It is important to investigate risk factors for these diseases among children, given evidence that they likely persist into adulthood (Berenson, Srinivasan, Xu, & Chen, 2016; Koskinen et al., 2017; Suglia et al., 2017).

Tracking risk factors from childhood to adolescence, and later to late adulthood is challenging. However, being overweight or obese during early childhood has been shown to increase the risk of being at an unhealthy weight in adulthood, as well as lifestyle diseases (Berenson, Srinivasan, & Nicklas, 1998; Berenson et al., 2016; Koskinen et al., 2017). There are strong indications that children who show signs of cardiometabolic risk factors may develop diabetes in adolescence and adulthood (Koskinen et al., 2017). Despite tendencies of a levelling out with regard to weight gain in children in some countries [6, 7], the trend of increased obesity and inactivity among children worldwide is still a major concern for public health. Norway is one of the few countries where there is a decrease in overweight children [8]. About 16 % of Norwegian children are however currently overweight or obese [7]. Measurements of 3<sup>rd</sup> grade pupils revealed that 14 % had experienced an unhealthy weight-gain [9]. Given these figures, it is of great importance to map cardiometabolic risk factors in early childhood in order to follow any development in a child population.

While individual risk factors may indicate current health status, the cumulative effect of multiple factors lead to lifestyle diseases. Early identification and intervention for children at risk of developing cardiometabolic diseases (CMD) could minimize the tracking of risk factors into adulthood [10, 11]. Bailey et al. report that good cardiorespiratory fitness during youth is related to lower CMD risk in adulthood [11], where clustering of CMD risk factors occurs in for example obese children [12]. While

definitions for metabolic syndrome are useful for diagnostic purposes, they only provide a dichotomized result. Tracking quantitative risk scores provide population-level assessments of soft-endpoints among child populations while measuring degree of clustering. Steene-Johannessen et al. found clustering of cardiovascular disease risk factors in 11.4% of a representative Norwegian child population [13]. More nationally representative studies covering multiple geographical areas are necessary both to monitor development and for accurate assessment of CMD risk status among Norwegian children.

Several risk factors have been used in different papers to estimate overall burden of future CMD [13]. Anthropometric variables like weight, body mass index (BMI), WC and body fat have previously been used [13, 14]. In addition, serum cholesterol, high density lipoprotein, triglycerides and micro C-reactive protein (mCRP) have been used to estimate clustering of CMD risk factors [13, 15, 16]. Blood pressure (BP), endurance tests and physical activity level have also been considered clinically relevant factors [17].

The main aim of the present study was to investigate the clustering of risk factors for cardiovascular diseases and the metabolic syndrome in a large, healthy representative Norwegian child population. In addition to the conventional dimensions of anthropometric measurements, biomarkers in blood samples and BP, the study also included an aerobic performance test and body composition variables.

## **Method**

### *Sample*

This paper employed a cross-sectional design. The cardiometabolic risk factors presented in this study are baseline findings (January-June 2015) from the larger prospective Health Oriented Pedagogical Project (HOPP) cohort study. Primary school children (n=2817) from Norway were invited to participate and written informed consent was obtained from 82% (n=2297) of the population, ranging from 6 to 12 years of age (table 1). HOPP's full study design can be found published by Fredriksen et al. and is therefore not detailed in this paper [18]. Relevant essentials are presented below.

### *Anthropometry and body composition*

Weight and body composition (muscle mass, body fat, bone mass, and protein mass) were measured with a Tanita MC-980MA (Tokyo, Japan) through bioelectrical impedance analysis, barefoot, in light clothing, subtracting 0.4kg to compensate for weight of the clothes [19]. A SECA 213 stadiometer (SECA GmbH, Germany) measured body height without shoes to the nearest 0.5cm [20]. Waist circumference (WC) was measured with a tape measure to the nearest 0.5cm at full expiration at the level of the umbilicus. BMI was calculated as weight divided by height squared and waist-height ratio (WHtR) as WC divided by height.

An automatic BP monitor (Model M6 Comfort IT, Intellisense HEM-7322U-E, Omron Healthcare Co., Ltd., Kyoto, Japan) with a cuff (Intelli Wrap Cuff, HEM-FL31, Omron Healthcare Co., Ltd., Kyoto, Japan) attached to their left upper-arm measured BP up to three times depending on failure to detect pressure, or if results were outside normal age-adjusted ranges. In case of three unsuccessful attempts, the BP was measured on the right arm until a successful test was confirmed. A retest was performed at a later occasion if results were still outside normal ranges.

### *Andersen fitness test*

Aerobic fitness was measured for all students using the Andersen intermittent running test [21]. The test is an indirect measure of  $VO_{2max}$ . School gymnasiums were used for administering the test in groups of 10-20 children, depending on number of supervisors present. The children ran back and forth to touch the walls/lines at intervals of 15 seconds of running and 15 seconds of rest, for a total of 10 minutes. Total distance was recorded as number of laps completed plus distance covered during the last lap. The children were told to run as fast as they could in order to cover the longest distance possible.

### *Blood samples*

Blood samples were collected for 1356 (59%) children in a non-fasting state between 08.00 am-01.30 pm. The children were called from their classrooms in groups of four, making sure they had not performed strenuous exercise prior to sample collection. Blood samples were collected by a phlebotomist in 4ml tubes (Vacuette Z Serum Sep Clot Activator and K<sub>2</sub>EDTA, Greiner Bio-One International, Austria) from the antecubital vein. The gel tubes were then set to coagulate for 30 min before centrifuged at 2000 G for 10 minutes. Samples were, at the end of each day, transported to Vestfold Hospital Trust (cert. NS-EN ISO 15189) for analyses according to standard laboratory procedures. Serum total cholesterol (TC) and high-density lipoprotein-cholesterol (HDL-C) were measured in Vitros 5600 or Vitros 5.1 (Ortho-Clinical Diagnostics, USA), and haemoglobin-A1c (HbA1c) in Tosoh G8 (Tosoh, Japan) with reagents from the supplier. Non-HDL-C was calculated as TC subtracted by HDL-C.

### *Statistical analyses*

All variables were normally distributed, mean values with standard deviation (SD), and 95% confidence intervals (CI) are presented for all variables. All analyses were completed using Statistical Package for the Social Sciences v24 (IBM SPSS, Armonk, N.Y. USA). Differences by age, sex, and clustering of risk factors were analyzed with parametric t-tests and analyses of variance (ANOVA). A p-value  $\leq .05$  was considered statistically significant.

The analytical model used in the present study, as described in Fredriksen et al., was adjusted from ten to five risk factors [18]. Clustering of cardiometabolic risk factors is defined as a ratio  $>1$  to a binomial distribution [22]. As such, additional factors above five resulted in a reduction of detection rate close to 0%, invalidating practical relevance. Additionally, multicollinearity of variables was investigated through Pearson's correlation test. A score  $>0.7$  was considered strongly correlated, whereupon one variable was selected for further analysis. Weight, BMI, muscle mass, and percentage of body fat correlated strongly with WC, and non-HDL-C with TC. mCRP was only clinically significant among obese children and

therefore irrelevant for the whole sample. Six key components were thus included in assessment of clustering of cardiometabolic risk factors: WC, systolic blood pressure (SBP), Andersen aerobic fitness test, TC, HDL-C, and HbA1c.

Despite a weak correlation between TC and HDL-C ( $r=0.026$ ,  $p<0.0001$ ), the biological correlation of the two would likely indicate collinearity in subsequent analyses. As HDL-C is a subcomponent of TC, being high-risk in one of these variables indicates a high probability for being so for the other variable as well. A ratio was therefore calculated (TC/HDL) for this study, as both variables are important risk factors for CMDs. This approach has been used in previous studies to represent blood lipid values where measurements of triglycerides are not available [23–25].

Defining clustering of CMD risk factors as a ratio to an expected binomial probability distribution is detailed by Andersen et al. [22]. A ratio  $>1$  indicates an occurrence of risk factors that is no longer random, notwithstanding cause. Expected distribution of probability from 0-5 risk factors are, respectively, 23.7%, 39.6%, 26.4%, 8.8%, 1.5%, and 0.1%. All variables were cleaned for input errors and divided in quartiles by age and sex. A CMD risk score from zero to five for each individual was derived by adding the number of variables in the least desirable quartile (highest for WC, SBP, TC, and HbA1c; lowest for aerobic fitness and HDL-C).

A converted correlation  $r$  based on Cohen's  $d$  shows effect size between those with and without clustering of risk factors [26].  $r = 0.2$ ,  $0.5$ , and  $0.8$  were roughly translated as small, moderate, and large effect sizes. The average sum of  $z$ -scores in each risk score category is also presented.

### *Ethical considerations*

The HOPP team physician followed up on any anthropometric or blood sample values outside normal ranges. In the case of abnormal values, parents and/or guardians were advised to contact their child's general practitioner for further follow-up. All children were given the option to opt out of any tests and were otherwise excluded if sick or absent from school on the day of testing.

## Results

### *Sample characteristics*

Of the HOPP population, 37.5% had completed all tests for the CMD risk factors (table 1). The main limiting factor for the sample size was the blood tests (n=1344), as there were over 2000 participants for the anthropometric and body composition measures. Both sex (boys=50.3%) and age was evenly distributed, with the lowest number of participants in the 6- and 12-year-old groups. Average sample age was 9.7 years (SD=1.7) with a WC of 63.4 cm (SD=7.7) and no significant sex differences.

### *Sex differences*

Boys had higher average muscle mass (0.9kg higher, 95%CI=0.2-1.6,  $p<0.05$ ), fat-free mass (1.1kg higher, 95%CI=0.4-1.8,  $p<0.01$ ), bone mass (0.1kg higher, 95%CI=0.1-0.2,  $p<0.0001$ ), and HDL-C (0.12mmol/L higher, 95%CI=0.07-0.16,  $p<0.0001$ ) than girls (table 2). Girls had higher percentage of body fat (3.0% higher, 95%CI=2.5-3.6), fat mass (1.0kg higher, 95%CI=0.6-1.4), and TC/HDL ratio (0.21 higher, 95%CI=0.1-0.3) ( $p<0.0001$ ). Additionally, boys ran significantly further (974 m, SD=144) than girls (939 m, SD=137) in the Andersen aerobic fitness test ( $p<0.0001$ ). There were no significant average sex differences for any of the anthropometric measures.

### *Sex differences by age*

Differences were found when stratifying sex by age (table 3). The Andersen aerobic fitness test results were different for the highest number of age groups, ranging from 24 m to 52 m further for boys ( $p<0.05$ ). Only the seven and twelve year olds had no significant differences in distance covered. WC was only different for the ten (2.8cm,  $p<0.05$ ) and twelve (3.2cm,  $p<0.001$ ) year olds, showing higher circumferences for the boys at both ages. No clinically relevant differences in SBP nor HbA1c was present in any age group. Girls had a significantly higher TC/HDL ratio in all age groups except among 7-

, 10-, and 12-year-olds by 0.22 to 0.34 ( $p < 0.05$ ). The highest TC/HDL ratio was among nine-year-old girls at 3.0 ( $SD = 0.7$ ,  $p < 0.001$ ) and is within a preferred range of  $< 3.5$  [27, 28].

ANOVA across age-groups revealed a significant increase with age ( $p < 0.001$ ) for all anthropometric variables, body composition, and cardiopulmonary variables except body fat percentage ( $p = 0.23$ ) (table 2 and 3). Among the blood values, only HbA1c was significantly higher among the older children compared to the younger ( $p < 0.05$ ).

### *Clustering of CMD risk factors*

Only those with zero risk factors were significantly over a risk ratio of one ( $RR = 1.21$ ,  $95\% CI = 1.05-1.40$ ) when comparing to the expected distribution (figure 2). Those with two factors in the least desirable quartile had a lower prevalence in HOPP than the expected binomial probability distribution ( $RR = 0.81$ ,  $95\% CI = 0.70-0.95$ ). Low sample sizes at four ( $n = 24$ ) and 5 ( $n = 6$ ) risk factors led to large confidence intervals at these levels. No clustering of CMD risk factors was found among the HOPP sample.

Results have been dichotomized by three and less risk factors and four or more risk factors based on findings from both the ASK- and EYHS-studies for comparison (table 4) [13, 29]. Those with four or more risk factors had a higher mean age (10.10 years,  $SD = 1.46$ ) than those with fewer (9.66 years,  $SD = 1.74$ ), though the difference was not significant ( $p = 0.11$ ).

Comparing mean values for the risk factors; WC was 22.8% higher, SBP 8.1% higher, Andersen aerobic fitness test 12.0% lower, TC/HDL ratio 45.6% higher, and HbA1c 3.9% higher among children with four or more risk factors than those with fewer than four risk factors ( $p < 0.0001$ ). There were no large effect sizes for any CMD risk factors, though both WC and TC/HDL ratio had medium differences, the rest showing small differences. Most of those with four or more risk factors were overweight (median isoBMI =  $25.0 \text{ kg/m}^2$ ), while most of those with fewer had a normal weight ( $18.5 \text{ kg/m}^2$ ) ( $p < 0.0001$ ) [8, 30]. z-scores at each risk factor category is presented in figure 1.

## Discussion

### *Main findings*

The present study found no clustering of CMD risk factors among children in Norway aged 6-12 years. A risk ratio of 5.8 (95%CI=0.7-46.9) was found at five risk factors, though the small sample size rendered results non-significant. An explorative analysis combining children with four and five risk factors does not reveal any significant clustering either. The null results of this observational study do not negate the importance of further research but reflects the complicated nature of tracking soft endpoints of CMDs, especially among younger children.

### *Cardiometabolic risk*

Two other Scandinavian studies, the EYHS-Denmark (1997-98) and ASK (2005-06) studies, had a clustering of cardiovascular risk factors at four and five or more factors (figure 3) [13, 29]. This inconsistency with HOPP results may be difficult to explain. However, age differences between the studies may be a contributing factor. Average age for the HOPP sample is lower than both EYHS and the ASK-study, which include adolescents at 15 years of age. Considering the higher sample mean age at four or more risk factors, despite the difference not being statistically significant (table 4), could suggest that risk of developing CMDs rise with increasing age.

The groups had no large differences but had a small difference for multiple anthropometric, cardiopulmonary, and blood values (table 4). Most noteworthy was perhaps that weight, WC, and TC/HDL ratio all had moderate differences, suggesting a tendency towards clustering for the four or more risk factors group. A paper published by Steinarsson et al. reported WC, SBP, HbA1c, TC, and HDL-C that were worse for all variables among a Swedish adult population aged 18-44 years of age where social health conditions are otherwise comparable to Norway [31, 32].

The use of quartiles for the cluster analysis had the benefit of identifying those children with an elevated risk for, but had not yet developed disease. Non-random clustering of risk factors is likely attributable to extraneous environmental factors. Lack of clustering among the HOPP sample can therefore indicate healthier behavioral patterns among the younger sample in the present study compared to both EYHS-Denmark and the ASK study [13, 29]. Suglia et al. suggests a conceptual model for cardiometabolic health in which childhood adversities (discrimination, bullying, economic hardships etc.) are at the foundation of developing unwanted health behaviors, poor mental health, and less efficient physiological mechanisms (eg. heightened cortisol production) [4]. All of these factors could systematically change in the children's environment with increasing age.

Another cause may be different cardiometabolic markers across various stages of life. Ali et al. report for example, that while waist adiposity alone remained a significant predictor of cardiometabolic health among children, visceral and subcutaneous fat along with WHtR remained significant among adults [33]. The varying influence of risk factors at different ages could stress the need for adapted risk factor profiles depending on the age group studied.

While the method is the same as Steene-Johannessen et al.'s study, the risk factor variables in the present study were regrettably not identical [13]. The variables are however recognized to have an equal impact on CMDs [14, 34, 35]. Regional variability may additionally be a likely cause. Van Vliet et al. reports that Norway is among the countries with the most favorable CMD risk factors worldwide [36]. That is, finding clustering of risk factors may only be true for certain subgroups of the population such as those with low socioeconomic status. Bugge et al. report that those with higher socioeconomic status had lower BMI z-scores, WC, and higher  $VO_{2max}$  [10].

Clinical relevance for these findings lie in their potential diagnostic value. Based on cumulative z-score at four or more risk factors in a representative population, researchers and health practitioners may assess increased risk in developing cardiovascular and metabolic diseases among children. In theory, any strongly correlated variables excluded from the clustering score can substitute each other. WC, WHtR,

and TC/HDL ratio had the highest effect sizes, meaning abdominal fat coupled with a poor serum cholesterol profile could be focuses in public health intervention strategies, as these had the largest between-group differences.

A major strength of the study is the large sample size, and subsequently age and gender specific quartile divisions. The goal of the study was to identify those in the "worst quartile" for selected variables, thus with an increased risk of disease development in the future. CMDs are long-term lifestyle diseases with potential tracking into adolescence and adulthood [10, 37]. The reporting of z-scores for clustering of risk factors reduces the specificity of having to use each risk factor included in this study, also theoretically allowing easier cross-population comparisons. Due to a low number of participants with four or more risk factors when split by age (n=2-7), the reporting of age-specific z-scores would prove little purpose. Their aggregated z-score is instead reported for one to three (-0.12, SE 0.07) versus four or more (3.81, SE 0.36) risk factors for the sake of future comparisons (table 4).

A limitation of reporting risk and z-scores based on quartiles is its sample specificity. Results are mostly representative of the sample it was based on. Adjustments for socioeconomic status, sex, and age distribution based on Norway's national population could increase representability. Analyses would unfortunately still be limited without adjusting for the prevalence of disease in the population. The nearest available statistic for a hard endpoint would be using the IDF definition for metabolic syndrome, for which there are national and global statistics [38]. Follow-up studies should crosscheck CMD risk scores with national metabolic syndrome prevalence and compare the degree to which these risk assessments overlap.

## **Conclusion**

No clustering of cardiometabolic risk factors was found among 6-12-years-old Norwegian children. Boys had however slightly more favorable TC/HDL ratio than girls and had better aerobic fitness.

## References

- [1] The GBD 2015 Obesity Collaborators. Health Effects of Overweight and Obesity in 195 Countries over 25 Years. *N Engl J Med* 2017; 377: 13–27.
- [2] Berenson GS, Srinivasan SR, Xu JH, et al. Adiposity and Cardiovascular Risk Factor Variables in Childhood Are Associated With Premature Death From Coronary Heart Disease in Adults: The Bogalusa Heart Study. *Am J Med Sci* 2016; 352: 448–454.
- [3] Koskinen J, Juonala M, Dwyer T, et al. Impact of Lipid Measurements in Youth in Addition to Conventional Clinic-Based Risk Factors on Predicting Preclinical Atherosclerosis in Adulthood: The International Childhood Cardiovascular Cohort (i3C) Consortium. *Circulation* 2017; CIRCULATIONAHA.117.029726.
- [4] Suglia SF, Koenen KC, Boynton-Jarrett R, et al. Childhood and Adolescent Adversity and Cardiometabolic Outcomes: A Scientific Statement From the American Heart Association. *Circulation* 2017; CIR.0000000000000536.
- [5] Berenson GS, Srinivasan SR, Nicklas TA. Atherosclerosis: a nutritional disease of childhood. *Am J Cardiol* 1998; 82: 22–29.
- [6] Júlíusson PB, Roelants M, Nordal E, et al. Growth references for 0–19 year-old Norwegian children for length/height, weight, body mass index and head circumference. *Ann Hum Biol* 2013; 40: 220–227.
- [7] Júlíusson PB, Eide GE, Roelants M, et al. Overweight and obesity in Norwegian children: prevalence and socio-demographic risk factors. *Acta Pædiatrica* 2010; 99: 900–905.
- [8] Cole TJ, Lobstein T. Extended international (IOTF) body mass index cut-offs for thinness, overweight and obesity. *Pediatr Obes* 2012; 7: 284–294.
- [9] 4.3. Utvikling av overvekt og fedme hos barn og unge. *Folkehelseinstituttet*, <http://www.fhi.no/nettpub/barnehelserapporten/helse-og-levevaner/utvikling-av-overvekt-og-fedme-blant/> (2016, accessed 17 November 2016).
- [10] Bugge A, El-Naaman B, McMurray RG, et al. Tracking of clustered cardiovascular disease risk factors from childhood to adolescence. *Pediatr Res* 2013; 73: 245–249.
- [11] Bailey DP, Boddy LM, Savory LA, et al. Associations between cardiorespiratory fitness, physical activity and clustered cardiometabolic risk in children and adolescents: the HAPPY study. *Eur J Pediatr* 2012; 171: 1317–1323.
- [12] Chu NF, Rimm EB, Wang DJ, et al. Clustering of cardiovascular disease risk factors among obese schoolchildren: the Taipei Children Heart Study. *Am J Clin Nutr* 1998; 67: 1141–1146.
- [13] Steene-Johannessen J, Kolle E, Anderssen SA, et al. Cardiovascular disease risk factors in a population-based sample of Norwegian children and adolescents. *Scand J Clin Lab Invest* 2009; 69: 380–386.

- [14] Abarca-Gómez L, Abdeen ZA, Hamid ZA, et al. Worldwide trends in body-mass index, underweight, overweight, and obesity from 1975 to 2016: a pooled analysis of 2416 population-based measurement studies in 128·9 million children, adolescents, and adults. *The Lancet*; 0. Epub ahead of print 10 October 2017. DOI: 10.1016/S0140-6736(17)32129-3.
- [15] Steene-Johannessen J, Kolle E, Reseland JE, et al. Waist circumference is related to low-grade inflammation in youth. *Int J Pediatr Obes IJPO Off J Int Assoc Study Obes* 2010; 5: 313–319.
- [16] Mehta SK. Waist Circumference to Height Ratio in Children and Adolescents. *Clin Pediatr (Phila)* 2015; 54: 652–658.
- [17] Poitras VJ, Gray CE, Borghese MM, et al. Systematic review of the relationships between objectively measured physical activity and health indicators in school-aged children and youth. *Appl Physiol Nutr Metab Physiol Appl Nutr Metab* 2016; 41: S197-239.
- [18] Fredriksen PM, Hjelle OP, Mamen A, et al. The health Oriented pedagogical project (HOPP) - a controlled longitudinal school-based physical activity intervention program. *BMC Public Health* 2017; 17: 370.
- [19] Tanita Co. BODY COMPOSITION ANALYZER MC-980MA - Instruction manual, <http://tanita.eu/media/wysiwyg/manuals/professional-body-composition-analysers/mc980ma-gb-101101.pdf> (2017, accessed 6 February 2017).
- [20] seca gmbh & co. kg. seca 213 manual, [https://www.seca.com/fileadmin/documents/manual/seca\\_man\\_213\\_int.pdf](https://www.seca.com/fileadmin/documents/manual/seca_man_213_int.pdf) (2014, accessed 6 February 2017).
- [21] Andersen LB, Andersen TE, Andersen E, et al. An intermittent running test to estimate maximal oxygen uptake: the Andersen test. *J Sports Med Phys Fitness* 2008; 48: 434–437.
- [22] Andersen LB, Lauersen JB, Brønd JC, et al. A New Approach to Define and Diagnose Cardiometabolic Disorder in Children. *J Diabetes Res*; 2015, <https://doaj.org> (2015, accessed 11 December 2017).
- [23] Bucheit JD, Helsing H, Nadpara P, et al. Clinical pharmacist understanding of the 2013 American College of Cardiology/American Heart Association cholesterol guideline. *J Clin Lipidol*; 0. Epub ahead of print 6 December 2017. DOI: 10.1016/j.jacl.2017.11.010.
- [24] Lemieux I, Lamarche B, Couillard C, et al. Total Cholesterol/HDL Cholesterol Ratio vs LDL Cholesterol/HDL Cholesterol Ratio as Indices of Ischemic Heart Disease Risk in Men: The Quebec Cardiovascular Study. *Arch Intern Med* 2001; 161: 2685–2692.
- [25] O'Connor LE, Kim JE, Campbell WW. Total red meat intake of  $\geq 0.5$  servings/d does not negatively influence cardiovascular disease risk factors: a systemically searched meta-analysis of randomized controlled trials. *Am J Clin Nutr* 2017; 105: 57–69.
- [26] Cohen J. *Statistical Power Analysis for the Behavioral Sciences*. 2 edition. Hillsdale, N.J: Routledge, 1988.

- [27] Cholesterol ratio: Is it important? *Mayo Clinic*, <http://www.mayoclinic.org/diseases-conditions/high-blood-cholesterol/expert-answers/cholesterol-ratio/faq-20058006> (accessed 12 January 2018).
- [28] Publishing HH. Making sense of cholesterol tests. *Harvard Health*, <https://www.health.harvard.edu/heart-health/making-sense-of-cholesterol-tests> (accessed 12 January 2018).
- [29] Andersen LB, Wedderkopp N, Hansen HS, et al. Biological cardiovascular risk factors cluster in Danish children and adolescents: the European Youth Heart Study. *Prev Med* 2003; 37: 363–367.
- [30] Cole TJ, Flegal KM, Nicholls D, et al. Body mass index cut offs to define thinness in children and adolescents: international survey. *BMJ* 2007; 335: 194.
- [31] McNamara CL, Balaj M, Thomson KH, et al. The socioeconomic distribution of non-communicable diseases in Europe: findings from the European Social Survey (2014) special module on the social determinants of health. *Eur J Public Health* 2017; 27: 22–26.
- [32] Torben M. Andersen, Bengt Holmström, Seppo Honkapohja, et al. *The Nordic Model: Embracing globalization and sharing risks*. Yliopistopaino, Helsinki. Finland: Taloustieto Oy, 2007.
- [33] Ali O, Cerjak D, Kent JW, et al. Obesity, central adiposity and cardiometabolic risk factors in children and adolescents: a family-based study. *Pediatr Obes* 2014; 9: e58–e62.
- [34] Ahrens W, Moreno LA, Mårild S, et al. Metabolic syndrome in young children: definitions and results of the IDEFICS study. *Int J Obes* 2014; 38: S4.
- [35] Cadby G, Melton PE, McCarthy NS, et al. Pleiotropy of cardiometabolic syndrome with obesity-related anthropometric traits determined using empirically derived kinships from the Busselton Health Study. *Hum Genet* 2017; 1–9.
- [36] van Vliet M, Heymans MW, von Rosenstiel IA, et al. Cardiometabolic risk variables in overweight and obese children: a worldwide comparison. *Cardiovasc Diabetol* 2011; 10: 106.
- [37] Brouwer SI, Stolk RP, Liem ET, et al. The role of fitness in the association between fatness and cardiometabolic risk from childhood to adolescence. *Pediatr Diabetes* 2013; 14: 57–65.
- [38] The IDF consensus worldwide definition of the metabolic syndrome, <http://www.idf.org/metabolic-syndrome> (2015, accessed 24 May 2016).

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Table 1: Population and sample distribution by age in the HOPP study

<b>Age</b>	<b>Population</b>	<b>HOPP sample</b>	<b>Complete CMD data*</b>	<b>Percent of population</b>
<b>6</b>	318	240	88	27.7%
<b>7</b>	445	354	135	30.3%
<b>8</b>	431	349	159	36.9%
<b>9</b>	481	402	176	36.6%
<b>10</b>	459	380	184	40.1%
<b>11</b>	511	426	230	45.0%
<b>12</b>	171	151	84	49.1%
<b>Total</b>	<b>2816</b>	<b>2302</b>	<b>1056</b>	<b>37.5%</b>

\* Represents number of participants who completed all six cardiometabolic disease (CMD) risk factor tests; waist circumference, Andersen fitness test, systolic blood pressure, total serum cholesterol, serum HDL-cholesterol, and serum HbA1c.

Table 2: Descriptives for cardiometabolic risk factors in 6-12 year old children

	Boys			Girls		
	n	Mean (SD)	95% CI	Mean (SD)	95% CI	
<b>Age (years)</b>	531	9.6 (1.7)	9.5-9.8	525	9.7 (1.7)	9.6-9.9
<b>Anthropometry</b>						
<b>Weight (kg)</b>	531	33.9 (8.7)	33.2-34.7	525	33.9 (9.3)	33.1-34.7
<b>Height (cm)</b>	531	139.9 (11.0)	139.0-140.9	525	140.0 (11.9)	139.0-141.0
<b>BMI (kg/m<sup>2</sup>)</b>	531	17.1 (2.6)	16.9-17.3	525	17.0 (2.6)	16.7-17.2
<b>Waist (cm)</b>	531	63.7 (7.5)	63.1-64.3	525	63.0 (7.8)	62.3-63.7
<b>WHR</b>	531	0.5 (0.0)	0.5-0.5	525	0.5 (0.0)	0.5-0.5
<b>Body composition</b>						
<b>Muscle mass (kg)</b>	527	25.6 (5.7)	25.1-26.1	524	24.7 (6.0)	24.2-25.2
<b>Fat (%)</b>	527	19.3 (4.8)	18.9-19.8	524	22.4 (4.3)	22.0-22.7
<b>Fat mass (kg)</b>	527	6.8 (3.4)	6.5-7.1	524	7.8 (3.5)	7.5-8.1
<b>Fat-free mass (kg)</b>	527	27.1 (6.0)	26.6-27.7	524	26.0 (6.3)	25.5-26.6
<b>Bone mass (kg)</b>	527	1.5 (0.3)	1.5-1.5	524	1.4 (0.3)	1.3-1.4
<b>Protein mass (kg)</b>	525	5.8 (1.3)	5.7-5.9	521	5.7 (2.6)	5.5-6.0
<b>Cardiopulmonary</b>						
<b>BPsys (mmHg)</b>	531	110 (10)	109-111	525	108 (10)	107-109
<b>BPdia (mmHg)</b>	531	71 (8)	70-71	525	71 (7)	71-72
<b>Andersen test (m)</b>	531	974 (144)	961-986	525	938 (137)	927-950
<b>Blood samples</b>						
<b>HbA1c (%)</b>	531	5.4 (0.3)	5.4-5.4	525	5.4 (0.2)	5.4-5.4
<b>TC (mmol/L)</b>	531	4.3 (0.6)	4.2-4.4	525	4.3 (0.7)	4.3-4.4
<b>HDL-C (mmol/L)</b>	531	1.69 (0.35)	1.66-1.72	525	1.58 (0.33)	1.55-1.61
<b>nonHDL-C (mmol/L)</b>	531	2.60 (0.65)	2.54-2.65	525	2.75 (0.66)	2.70-2.81
<b>TC/HDL ratio</b>	531	2.6 (0.6)	2.6-2.7	525	2.8 (0.7)	2.8-2.9
<b>mCRP (mg/L)</b>	221	1.11 (2.29)	0.81-1.41	229	1.27 (3.51)	0.82-1.73

BMI=body mass index; BPsys=systolic blood pressure; BPdia=diastolic blood pressure; HbA1c=glycated haemoglobin; TC=total cholesterol; HDL-C=high-density lipoprotein cholesterol; nonHDL-C=non-high-density lipoprotein cholesterol; mCRP=micro C-reactive protein.

Table 3: Descriptives of cardiometabolic risk factors by age and gender

	Age	6	7	8	9	10	11	12
	<b>n (boys)</b>	88 (46)	135 (72)	159 (77)	176 (94)	184 (85)	230 (114)	84 (43)
<b>Waist (cm)*</b>	<b>Total</b>	56.95 (4.61)	59.25 (5.4)	60.50 (5.35)	62.88 (7.22)	65.51 (7.9)	67.10 (7.97)	67.97 (6.41)
	<b>Boys</b>	56.49 (3.38)	59.74 (5.58)	61.17 (5.17)	63.41 (6.48)	67.00 (8.83)	66.37 (6.78)	69.55 (7.16)
	<b>Girls</b>	57.45 (5.67)	58.70 (5.17)	59.88 (5.47)	62.28 (7.99)	64.22 (6.78)	67.82 (8.96)	66.32 (5.08)
<b>BPsys (mmHg)*</b>	<b>Total</b>	103.45 (9.57)	105.17 (10.59)	107.51 (9.3)	108.74 (9.2)	110.71 (9.99)	111.70 (10.42)	113.57 (11.07)
	<b>Boys</b>	104.37 (9.43)	105.64 (10.93)	109.78 (8.62)	109.48 (8.64)	111.27 (10.53)	112.16 (10.60)	114.44 (12.09)
	<b>Girls</b>	102.45 (9.74)	104.63 (10.24)	105.38 (9.45)	107.89 (9.78)	110.22 (9.53)	111.25 (10.26)	112.66 (9.96)
<b>Andersen test (m)*</b>	<b>Total</b>	775.69 (109.78)	851.59 (108.26)	926.84 (121.63)	965.83 (121.3)	993.68 (123.43)	1022.26 (109.79)	1084.70 (106.82)
	<b>Boys</b>	786.89 (114.28)	860.75 (105.77)	943.87 (125.03)	989.93 (114.86)	1015.55 (134.16)	1048.12 (105.94)	1098.42 (90.64)
	<b>Girls</b>	763.43 (104.62)	841.11 (110.96)	910.85 (116.86)	938.21 (123.27)	974.90 (110.68)	996.84 (107.98)	1070.32 (120.99)
<b>HbA1c (%)*</b>	<b>Total</b>	5.32 (0.19)	5.35 (0.28)	5.39 (0.2)	5.41 (0.37)	5.35 (0.24)	5.39 (0.22)	5.42 (0.23)
	<b>Boys</b>	5.32 (0.18)	5.36 (0.27)	5.37 (0.21)	5.43 (0.45)	5.36 (0.26)	5.40 (0.21)	5.40 (0.22)
	<b>Girls</b>	5.31 (0.21)	5.33 (0.30)	5.41 (0.18)	5.38 (0.24)	5.35 (0.23)	5.39 (0.23)	5.43 (0.24)
<b>TC/HDL ratio</b>	<b>Total</b>	2.72 (0.64)	2.65 (0.71)	2.69 (0.61)	2.78 (0.68)	2.78 (0.63)	2.75 (0.67)	2.70 (0.66)
	<b>Boys</b>	2.58 (0.68)	2.62 (0.78)	2.58 (0.63)	2.62 (0.64)	2.72 (0.60)	2.60 (0.55)	2.69 (0.63)
	<b>Girls</b>	2.88 (0.56)	2.69 (0.62)	2.80 (0.56)	2.96 (0.68)	2.84 (0.65)	2.90 (0.75)	2.72 (0.70)

\*Significant age differences for totals at  $p < .05$  in an ANOVA.

Table 4: Clustered descriptives of cardiometabolic disease risk factors.

	1-3 risk factors (n=1026)		4+ risk factors (n=30)		Cohen's d **
	Mean (SD)	95% CI	Mean (SD)	95% CI	
<b>Age (years)</b>	9.7 (1.7)	9.6-9.8	10.1 (1.5)	9.6-10.7	0.25
<b>Anthropometric</b>					
<b>Weight (kg)</b>	33.5 (8.6)	33.0-34.1	46.2 (13.5)	41.1-51.2	1.47
<b>Height (cm)</b>	139.8 (11.4)	139.1-140.5	144.3 (11.0)	140.2-148.4	0.39
<b>BMI (kg/m<sup>2</sup>)</b>	16.9 (2.4)	16.7-17.0	21.8 (4.3)	20.1-23.4	2.07
<b>isoBMI (median kg/m<sup>2</sup>)</b>	18.5		25.0		
<b>Waist (cm)</b>	62.9 (7.1)	62.5-63.4	77.3 (12.3)	72.7-81.9	2.02
<b>WHtR</b>	0.45 (0.04)	0.45-0.45	0.53 (0.06)	0.51-0.56	2.06
<b>Cardiopulmonary</b>					
<b>BPsyst (mmHg)</b>	109 (10)	108-109	118 (10)	114-121	0.86
<b>BPdia (mmHg)</b>	71 (8)	71-72	71 (7)	68-73	-0.05
<b>Andersen test (m)</b>	959 (141)	951-968	845 (106)	805-884	-0.81
<b>Blood samples</b>					
<b>TC (mmol/L)</b>	4.3 (0.6)	4.3-4.3	4.9 (0.9)	4.6-5.3	0.98
<b>HDL-C (mmol/L)</b>	1.65 (0.34)	1.63-1.67	1.30 (0.34)	1.18-1.43	-1.01
<b>TC/HDL ratio</b>	2.7 (0.6)	2.7-2.7	3.9 (0.8)	3.6-4.2	1.98
<b>HbA1c (%)</b>	5.4 (0.3)	5.4-5.4	5.6 (0.2)	5.5-5.7	0.78
<b>Risk factors z-score*</b>	-0.12 (2.16)	-0.25-0.01	3.81 (1.96)	3.08-4.54	1.82

BMI=body mass index; BPsyst=systolic blood pressure; BPdia=diastolic blood pressure; HbA1c=glycated haemoglobin; TC=total cholesterol; HDL-C=high-density lipoprotein cholesterol.

\* Average sum of z-scores of waist circumference, BPsyst, Andersen aerobic fitness test, TC/HDL ratio, and HbA1c.

\*\* Base is "1-3 risk factors"-group's SD.

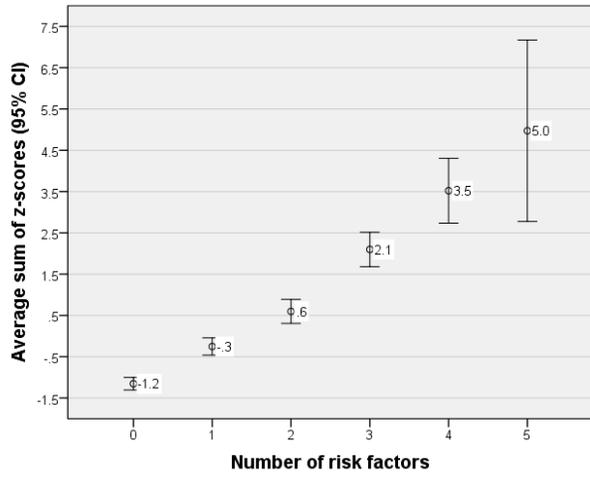


Figure 1: Average sum of z-scores by clustered cardiometabolic risk factors.

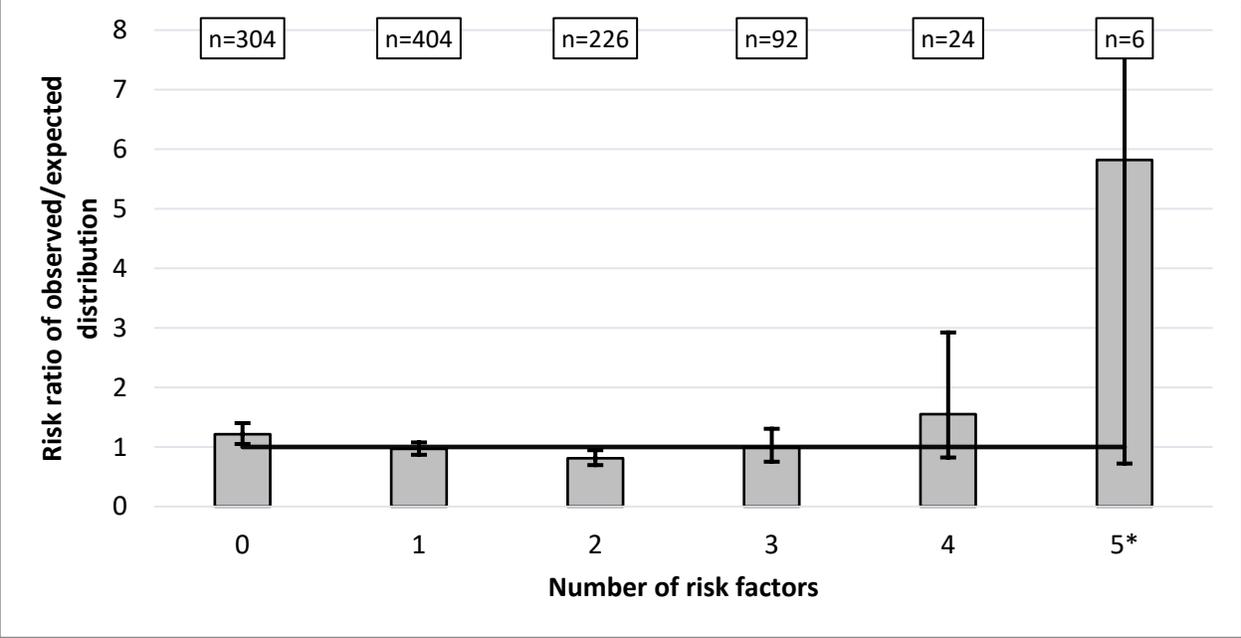


Figure 2: Ratio of observed/expected distribution by number of cardiometabolic risk factors.

Distribution of observed number of cardiometabolic risk factors in least favourable quartile as binomial data against a binomial probability distribution.

\* Upper boundary of 95%CI = 46.9.

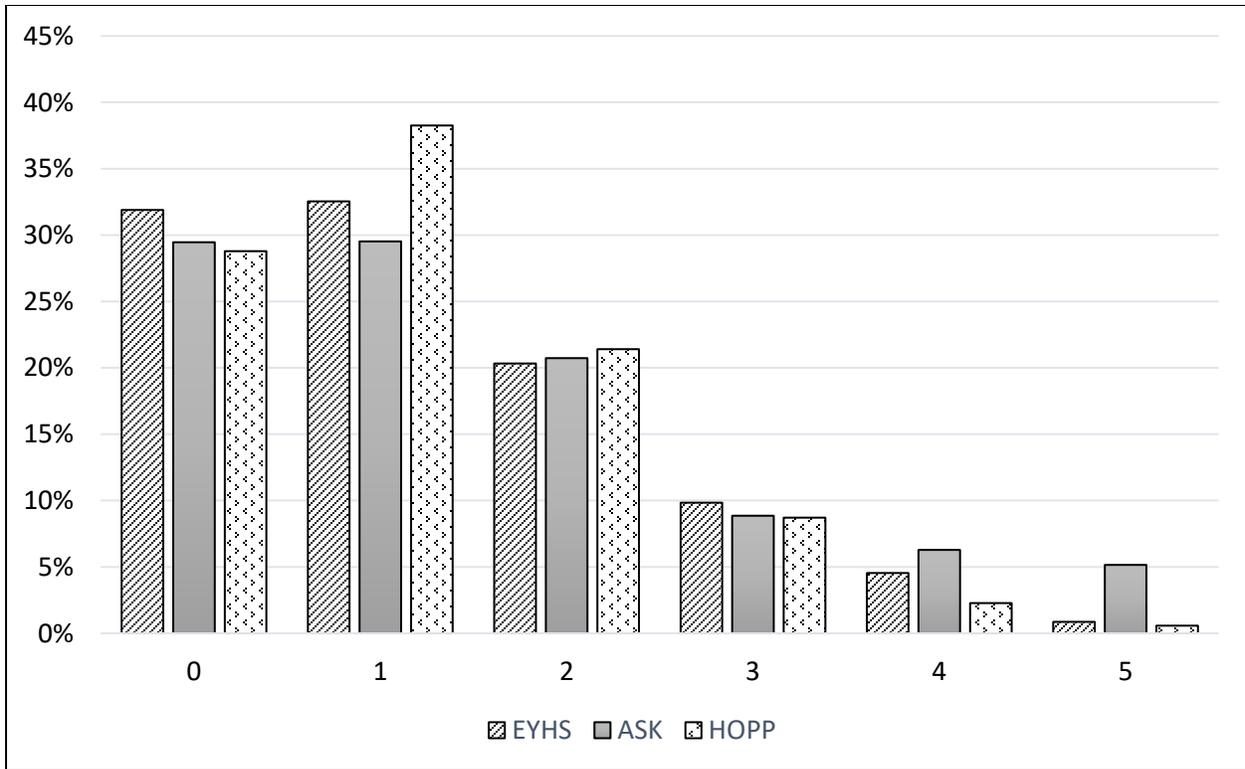


Figure 3: Comparison of EYHS-Denmark, ASK, and HOPP sample distribution by number of cardiometabolic risk factors.

# Appendix 1: Information to parents for recruitment

(page 1)

**Betraktninger omkring etikk og risiko**  
Kjennskap til fysisk form og helse vil være nyttig for barn og foresatte i forhold til å planlegge for en sunn utvikling, og deltakelse i prosjektet er således å anses som en fordel for barn og foreldre. Malingerne og testene innebærer liten eller ingen risiko for skader eller ubehag i forbindelse med selve gjennomføringen. Derimot krever kondisjonstesten en maksimal fysisk innsats.

Ditt barn vil ved deltakelse i dette prosjektet få kartlagt viktige fysiske og psykiske variabler. Hvis det mot formodning skulle vise seg at ditt barn avviker fra normalverdier på de testene som gjennomføres vil dere få beskjed om dette via prosjektets lege. Hvis dere ikke hører noe er verdiene vurdert til å være normale.

Hva skjer med prøvene og informasjonen om deg/ditt barn?  
Testresultatene blir oppbevart i beskyttet elektronisk form (passord beskyttet) og papirform (innlåst) i hele prosjektperioden. Etter at prosjektet er ferdig vil dataene bli makulert. Barn og foresatte kan få tilgang til resultater etter at studien er ferdigstilt. Prøvene som er tatt og informasjonen som registreres skal kun brukes slik som beskrevet i hensikten med studien. Blodprøvene blir destruert umiddelbart etter analysen.

Alle opplysninger og prøver vil bli behandlet uten navn og fødselsnummer eller andre direkte gjenkjennende opplysninger. En kode knytter person og opplysninger/prøver gjennom en navnliste. Det er kun autorisert personell knyttet til prosjektet som har adgang til navnlisten og som kan finne tilbake til bestemte personer. Det vil ikke være mulig å identifisere individer i resultatene til studien når disse publiseres.

Dersom du ønsker å delta i evalueringstudien, undertegner du samtykkeklæringen som vil bli sendt deg/dere ved hjelp av ranselpost og returnerer denne så snart som mulig. Vi kan ikke foreta noen tester på ditt barn uten at dette samtykket foreligger forut for første test. Det er frivillig å delta i evalueringstudien og du kan når som helst og uten å oppgi noen grunn trekke ditt samtykke til å delta i evalueringstudien.

Hvis du ønsker mer informasjon om studien så ta kontakt med:

Lars Erik Braaun  
Kontaktperson HOPP-prosjektet  
Telefon: 98 86 49 37  
E-post: HOPP-NICK@gmail.no

Helle Synnøve Knutson  
Kontaktperson HOPP-prosjektet  
Telefon: 98 44 45 15  
E-post: HOPP-NICK@gmail.no

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**Forespørsel om ditt barns deltakelse i evalueringstudien - Helsefremmende oppvekst i Horten kommune (HOPP)**

**Informasjon til foreldre**

**Bakgrunn og hensikt**  
Fysisk aktivitet samtidig med undervisning har vist seg å være gunstig for læring og kunnskapstillegg. Sett i sammenheng med at forekomsten av inaktivitet og overvekt har gått opp blant barn og unge de siste ti-årene vil akt fysisk aktivitet og et fornuftig kosthold være med på å dempe denne utviklingen. Horten kommune har som en konsekvens av dette satt i gang et stort prosjekt – HOPP - som inkluderer barnehager, SFO, barneskoler og fritidsaktiviteter i Horten kommune. Norges Helsehøyskole har blitt bedt om å evaluere effekten i deler av HOPP-prosjektet. Delprosjektet Aktiv Læring er spesielt rettet mot barneskolene og har til hensikt å gi et bedre læringsstilbud til elevene, samtidig med økt mengde fysisk aktivitet i skoletiden.

Prosjektets hensikt er dermed å evaluere de tiltakene som HOPP-prosjektet setter i gang i alle barneskolene i Horten kommune.

**Hva innebærer studien?**  
Det er laget egne undervisningsopplegg til alle lærere i barneskolene (Aktiv Læring) hvor målet er å ha 60 minutter fysisk aktivitet hver skoledag samt egne opplegg for kostholdsundervisning. Dette skal settes i gang på alle barneskolene i Horten kommune fra skolestart 2015. For å evaluere effekten av disse tiltakene vil det bli gjennomført flere målinger/tester for tiltakene settes i gang. Testene vil bli gjennomført i skoletiden. Oksygenopptaketene for 1.klassingene gjennomføres på ettermiddags/veid slik at foreldre har mulighet til å være med.

Undersøkelsene vil bli foretatt skolevis med fortløpende informasjon på mail, ranselpost og foreldremøte. Plan for undersøkelsene for ditt barns skole er vedlagt denne mail.

Evalueringsskjemaet vil vedvare til og med våren 2020. Det betyr at de som nå går i 1.klasse foretatt hvert år frem til ditt barn går ut av barneskolen. Det betyr at de som nå går i 1.klasse vil bli undersøkt en gang i året så lenge de går på barneskolen. De andre kullene blir testet tilsvarende de antall år de har igjen på barneskolen. Barna vil bli påmontert en aktivitetssensor som registrerer all fysisk aktivitet, og 4.klasse skal også fylle ut spørreskjema om kosthold.

Vedlagt denne mail er spørreskjema til foreldre om barnets aktiviteter utenom skolen og ditt barns psykiske helse. Skjemaene tar kun 5 minutter å fylle ut. Skjemaet er laget i Oneback-format og er anonymisert ved hjelp av en personlig kode for ditt barn. Denne koden må føres på skjemaet ved innlogging.

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# Appendix 1: Information to parents for recruitment

(page 2)

### Utdypende forklaring av hva evalueringsstudien innebærer

**Formål**  
Formålet med studien er å kartlegge effekt av implementering av aktiv læring i skolen. Elevene skal øke sin mengde fysisk aktivitet i skolehverdagen med én time hver dag. De vil i tillegg opprettholde de vanlige to timene med kroppsøving i uken og den aktiviteten de har i friminuttene.

**Målinger/spørreskjema som utføres i uken før gymnaslestedene**

- Fysisk aktivitetsnivå vil bli målt med et akselerometer som bæres rundt hoftekammen i en uke.
  - Denne blir montert på i et eget belte som barnet ditt skal ha på seg i én uke.
  - Måleren blir tatt av igjen når de kommer til gymnaslestedene.
- Blodprøve blir tatt for måling av blant annet kolesterolnivå, langtidssukker, jern, ferritin, hemoglobin og hematokrit.
  - Dette blir gjennomført i klasserommene uken før gymnaslestedene og samtidig med monterning av aktivitetsmonitoren.
  - Barn som vegrer seg for å ta blodprøve kan være med på resten av testingen selv om de reserverer seg mot blodprøve
- De nasjonale prøvene på 5.klassing vil bli brukt til å fastsette det akademiske nivået på skolenivå.
  - Dette er obligatoriske prøver som skolene gjennomfører årlig for 5.klassinger
- Spørreundersøkelse om kostholdsvaner (4.klasse)
- Dette er et spørreskjema som er benyttet nasjonalt i prosjektet Ungkost 2000.
- Oppmerksomhet/kognisjonstester (2.klasse og 6.klasse)
  - Dette er individuelle tester som tester konsentrasjon og oppmerksomheten til barna.

**Målemetoder som gjennomføres i gymnasl**

- Spørreundersøkelse om psykisk helse
- Høyde og kroppsmasseasammensetning
- Blodtrykk
- Lungefunksjon
- Håndstyrke
- Måling av eksplosiv styrke (spens)
- Balansetest (Y-testen)
- Kondisjonstest
  - 1.klasse vil i tillegg gjennomføre en maksimal oksygenopptaketest på tredemølle

Første test vil starte opp for den første skolen i januar/februar, deretter fortløpende utover våren. Prosjektstart med aktiv læring vil være skolestart i 2015. Første re-test skjer i januar til juni 2016, deretter gjenntas disse testene hver vinter/vår frem til 2020. Ditt barn blir dermed testet hvert år så lenge det går på barneskolen.

**Hvem er med?**  
Inklusjonskriterier

- Alle elever ved barneskoler i Horten kommune

Ekklusjonskriterier

- Elever med psykisk/mental utviklingshemning
- Elever med en fysisk utviklingshemning som forhindrer deltakelse i fysiske tester
- Elever med sykdom på testtidspunkt
- Elever som ikke ønsker å delta i testingen

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o De vil allikevel delta i implementeringen av det pedagogiske tilbudet da dette er et obligatorisk læringsverktøy initiert fra Horten kommune

**Risiko/etikk**  
Det regnes ikke som sannsynlig med bivirkninger av målingene, testene eller prøvetagningen, men det er knyttet en liten risiko for skader i kondisjonstesten knyttet til fall og det å anstrenge seg maksimalt. Utholdenhetstest kan medføre litt ubehag, det samme kan et spreytestikk.

Av deltagere forventes det deltagelse på alle tester/målinger man er i stand til å gjennomføre/ikke har reservert seg mot.

Alle resultater som mot formodning blir ansett som utenfor normverdi eller anses som en risikofaktor vil bli rapportert til deg som forelder via prosjektets lege.

**Personvern, økonomi og forsikring**

**Personvern**  
Norges Helseøyskole, ved instituttleder, er databehandlingsansvarlig. Opplysninger og resultater som registreres om ditt barn vil ikke kobles ikke opp mot andre registre. Alle som får innsyn har taushetsplikt. Ingen opplysninger vil bli utlevert til andre. Alle resultater blir anonymisert før publisering i artikler og rapporter.

Hvis du sier ja til at ditt barn kan delta i studien, har du rett til å få innsyn i hvilke opplysninger som er registrert om ditt barn. Du har videre rett til å få korriger eventuelle feil i de opplysningene vi har registrert. Dersom du trekker ditt barn fra studien, kan du kreve å få slettet innsamlende prøver og opplysninger, med mindre opplysningene allerede er inngått i analyser eller brukt i vitenskapelige publikasjoner. Du har rett til å få informasjon om resultatet av studien.

**Økonomi**  
Studien finansieres av Norges Helseøyskole og Horten kommune. Det er ingen interessekonflikter i denne studien.

**Forsikring**  
Deltagerne i studien er dekket gjennom en særskilt forsikring ved Norges Helseøyskole. Denne dekker eventuelle skader på deltakere under forsøksperioden.

Vi gleder oss til et spennende prosjekt og ser frem til et godt samarbeid.

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# Appendix 2: Information to children for recruitment



Norges Helsehøyskole  
Campus Trondheim



ORTEN  
Helseprosjektet

**Hei - vil du være med på en undersøkelse?**

Her er en beskrivelse av HOPP-prosjektet. HOPP står for Helsefremmende oppvekst i Horten kommune.

**Hvorfor skal vi gjøre dette?**  
Stadig flere barn beveger seg for lite. Vi ønsker at barn skal bevege seg mer og spise sunnere, samtidig som de skal lære bedre. I HOPP-prosjektet kan vi undersøke om vi kan gjøre noe med det. Da trenger vi hjelp av deg!

**Hva skal vi gjøre?**  
Du skal fortelle hva du skal trene fysisk aktivt mens du leger (dekt i løring) i 60 minutter hver skoledag. Du skal fortelle om det starter du med eller sammen med. I tillegg vil du bli lurt opp i hva som er lurt å spise. Vi kommer bli å gjøre undersøkelser på denne vinterferien og hver vinterferie frem til du er ferdig på barneskolen. Disse målingene blir gjort i klasserommet ditt og i gymsalen på skolen din sammen med de andre i klassen din.

Du skal måle:

- Høyden din
- Kroppssammensetningen din
- Blodtrykket ditt
- En blodprøve som måler hvor mye blod du har, hvor mye jern du har, og andre ting
- Lungefunksjonen din
- Hvor sterk du er
- Balansen din
- Hvor høyt du kan hoppe
- Hvor fort hjertet ditt kan slå
- Hvor uholdende du er (kondisjon)
- Hvor mye du beveger deg i løpet av en hel uke
- Spørreundersøkelse om hva du pleier å spise
- Spørreundersøkelse om hvordan du har det

**Hva får du ut av det?**  
Å vite hvor god form man har, kan være nyttig. Noen av målingene kan være litt slitsomme, men de fleste synes det er gøy. Kondisjonstesten krever at du tar i alt du kan.

**Hva skjer med prøvene og informasjonen om deg?**  
Blodprøvene blir undersøkt med en gang, deretter kaster vi resten. De vi måler vil ikke kunne sees av noen andre. Vi besikter målingene med en kode på datamaskinen og låser inn papirene. Du og dine foreldre kan se på resultatene etter at studiet er ferdig. Prøvene som er tatt og informasjonen som registreres skal kun brukes slik som beskrevet i hensikten med studien.

Alle opplysningene og prøvene vil bli bokstrevet med navn og fødselsnummer. Vi lagrer en kode som kobler deg og de testene vi tar til en navnliste. Der er kun vi i prosjektet som har adgang til navnlisten og som kan finne tilbake til bestemte personer. Det betyr at det bare er vi som undersøker deg som kan se hva du har gjort og ingen andre.

Det er frivillig å delta i undersøkelsen. Det betyr at hvis du ikke vil, så behøver du ikke være med. Hvis du ikke vil ha blodprøve så kan du være med på alle de andre undersøkelsene alihverd.

**Du kan når som helst og uten å oppgi noen grunn trekke ditt samtykke til å delta i undersøkelsen.**

Hvis du ønsker mer informasjon om studien så ta kontakt med:

Lars Erik Braum  
Kontaktperson HOPP-prosjektet  
Tlf: 93 86 49 37  
E-post: HOPP@HCK@nhk.no

Helle Synnøve Knutsen  
Kontaktperson HOPP-prosjektet  
Tlf: 93 41 15 15  
E-post: HOPP@HCK@nhk.no

**Her er bilder av noen av undersøkelsene:**

**Almtriksmonitor** - som du skal ha på deg en uke. Den er veldig liten (som en fyrstikkese) og festes i et belte som følger med. Denne blir satt på en uke for de andre undersøkelsene.



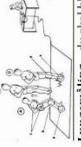
**Balanse** - du skal balansere på ett ben og skyve en kloss fremover, bakover og til siden.



**Stryketest** - du skal klemme så hardt du kan på en styrkemåler.



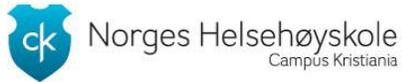
**Spenseshopp** - du skal hoppe så høyt du kan på en matte.



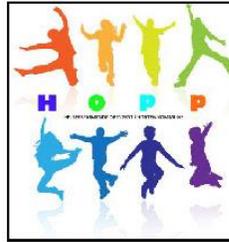
**Lungemåling** - du skal blåse så hardt du kan gjennom dette røret



## Appendix 3: Informed consent forms



Norges Helsehøyskole  
Campus Kristiania



### Samtykkeskjema til deltakelse i HOPP-studien

Viser til informasjon angående HOPP-prosjektet sendt forelder/foresatte per e-post. Samtykkeskjemaet må signeres og returneres til skolen for deltakelse i prosjektet. Det bemerkes at skjemaet har to (2) punkter som det må samtykkes i; tillatelse til å foreta blodprøver og tillatelse til å delta i selve prosjektet. Det er ikke påkrevd å samtykke i blodprøve for å delta i prosjektet.

Jeg har mottatt skriftlig og muntlig informasjon om studien og sier meg villig til å la mitt barn delta i HOPP-studien

Blodprøve tillates (kryss av hvis ja)

-----  
Barnets navn, skole og klasse (i blokkbokstaver)

-----  
(Signert av forelder/foresatte, dato)

## Appendix 4: Data collection forms

Registreringskjema HOPP-prosjektet 2015-2021								
ID-nr		Samtykke (sett ring)		Ja	Nei	Testår	201	
Klasseromtester								
Høyde	cm:	Midjemål			cm:	Kjønn	M/K	
Blodprøve	RBC	Hb	Blodsukker	Jern	Feritin	Aktivitets monitor	Ja	Nei
Spørreskjemaer								
Fysisk aktivitet (foreldre)	Ja	Nei	ILC (foreldre)	Ja	Nei	ILC (alle barna)	Ja	Nei
Flanker (3.klasse)	Ja	Nei	Stroop (5-7 kl)	Ja	Nei	SDQ (5-7 kl)	Ja	Nei
Kosthold (4.klasse)	Ja	Nei						
Gymsaltester								
Blodtrykk	Sys:	Dia:	Styrke	Høyre:	Venstre:			
Vekt	kg:		Muskel masse	kg:		BMI		
Kroppsmasse	Fettprosent:	Fettmasse:	Fettfri masse	Visceralt fett:	Benmasse:	Protein:		
Andersen test	Metar:							
O2-test (1.klasse)	VO2max:	BRmax:	RER:	VEmax:	VE/VCO2:	OUES:	HRmax:	Tid:

## Appendix 5: Andersen fitness test form

Andersen testen										Navn:	
Kode:	Dato:			Gyldig			Ugyldig			Usikker	
1	2	3	4	5	6	7	8	9	10		
11	12	13	14	15	16	17	18	19	20		
21	22	23	24	25	26	27	28	29	30		
31	32	33	34	35	36	37	38	39	40		
41	42	43	44	45	46	47	48	49	50		
51	52	53	54	55	56	57	58	59	60		
61	62	63	64	65	66	67	68	69	70		
71	72	73	74	75	76	77	78	79	80		
Kommentarer (sko/uten sko, løpermønster, avbrudd i test, sykdom, og lignende):										Meter siste runde:	

# Appendix 6: Ungkost-2000 food frequency questionnaire

(page 1)

**9. Utenom skoletid: Hvor ofte driver du idrett, eller mosjonerer du så mye at du blir andpusten og/eller svett? (Sett ett kryss?)**

Aldri  
 Mindre enn en gang i mnd.  
 1-3 ganger i mnd.  
 En gang i uka  
 2-3 ganger i uka  
 4-6 ganger i uka  
 Hver dag

**10. Utenom skoletid: Hvor mange timer i uka driver du idrett, eller mosjonerer så mye at du blir andpusten og/eller svett? (Sett ett kryss?)**

Ingen  
 omtrent 1/2 time  
 omtrent 1 time  
 omtrent 2-3 timer  
 omtrent 4-6 timer  
 7 timer eller mer

**11. Utenom skoletid: Hvor mange timer per dag pleier du å se på TV og/eller sitte foran PC-en? (Sett ett kryss?)**

Ikke i det hele tatt  
 mindre enn en 1/2 time om dagen  
 1/2-1 time  
 2-3 timer  
 4 timer  
 mer enn 4 timer

**12. Hvilken utdanning har din mor og far? (Sett ett kryss for høyest fullførte utdanning hos mor og ett kryss for høyest fullførte utdanning hos far)**

9-årig skole eller kortere	Mor	<input type="checkbox"/>	Far	<input type="checkbox"/>
Grunnkurs/ett-årig utdanninge utover 9-årig skole		<input type="checkbox"/>		<input type="checkbox"/>
Videregående skole/gymnas/yrkesskole (3 årig)		<input type="checkbox"/>		<input type="checkbox"/>
Høyskole- eller universitetsutdanning på 4 år eller mindre		<input type="checkbox"/>		<input type="checkbox"/>
Høyskole- eller universitetsutdanning på mer enn 4 år		<input type="checkbox"/>		<input type="checkbox"/>
Annet		<input type="checkbox"/>		<input type="checkbox"/>

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**Kort spørreskjema**

**1. Alder:**  år

**2. Kjønn:**  Jente  Gutt

**3. Høyde:**  cm **Vekt:**  kg

**4. Passer noe av dette for deg? (Sett ett kryss for hver linje)**

Spiser vanlig "norsk" kost	Ja <input type="checkbox"/>	Nei <input type="checkbox"/>
Er vegetarianer/vegane	<input type="checkbox"/>	<input type="checkbox"/>
Har diabetes (sukkersyke)	<input type="checkbox"/>	<input type="checkbox"/>
Har matvareallergi	<input type="checkbox"/>	<input type="checkbox"/>
Forsøker å gå ned i vekt	<input type="checkbox"/>	<input type="checkbox"/>
Har spesiell diett av andre grunner	<input type="checkbox"/>	<input type="checkbox"/>
Annet <input type="text"/>	<input type="checkbox"/>	<input type="checkbox"/>

**5. Hva syns du om vekta di? (Sett ett kryss)**

Den er passe   
Jeg veier for mye   
Jeg veier for lite

**6. Røyker du? (Sett ett kryss)**

Nei   
Ja, av og til   
Ja, daglig

**7. Tror du kostholdet spiller noen rolle for helsa di? (Sett ett kryss)**

Nei   
Ja, men ikke nå, bare når jeg blir eldre   
Ja, både nå og seinere i livet   
Vet ikke

**8. Hvordan vurderer du ditt eget kosthold? (Sett ett kryss)**

Det er veldig sunt   
Det er ganske sunt   
Det er usunt   
Vet ikke

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# Appendix 6: Ungkost-2000 food frequency questionnaire

(page.2)

**17. Hvor mange ganger spiser du følgende matvarer? (Sett ett kryss for hver matvare)**

	Altid/ Spjelden	1-3 ganger per mid per uke	4-6 ganger per uke	1 gang per dag	2 ganger per dag	3 ganger per dag	4 ganger eller flere per dag
Kokte poteter	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Pommes frites	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Gronnsaker	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Frukt, bær	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Grovbrød	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Pizza	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Hamburger/poise med brød/kebab	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Godterier	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Sjokolade	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Potetgull o.l.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Peanøtter	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Tran, trankapsler	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Vitamintilskudd	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

ID nummer, internet bruk

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**13. Hvor ofte pleier du å spise følgende måltider i løpet av en uke? (Sett ett kryss for hvert måltid)**

	Altid/ Spjelden	1 gang i uken	2 ganger i uken	3 ganger i uken	4 ganger i uken	5 ganger i uken	6 ganger i uken	Hver i uken dag
Frokost	<input type="checkbox"/>							
Formiddagsmat/lunsj	<input type="checkbox"/>							
Middag	<input type="checkbox"/>							
Kveldsmat	<input type="checkbox"/>							

**14. Hvis du spiser formiddagsmat/lunsj på hverdagene, hvor ofte spiser du følgende i løpet av en uke? (Sett ett kryss for hver linje)**

	Altid/ Spjelden	1 gang i uken	2 ganger i uken	3 ganger i uken	4 ganger i uken	5 ganger i uken
Matpakke hjemmefra	<input type="checkbox"/>					
Kjøper mat i kantine/matbod på skolen	<input type="checkbox"/>					
Kjøper mat fra butikk/kiosk i nærheten	<input type="checkbox"/>					

**15. Hvor mye drikker du vanligvis av følgende drikker? (Sett ett kryss for hver drikk) (3 glass=1/2 liter)**

	Drikk	1-3 glass per uke	4-6 glass per uke	1-3 glass per dag	4-6 glass per dag	7 glass eller mer per dag
Heimelk (søt/sur)	<input type="checkbox"/>					
Lettmelk (søt/sur)	<input type="checkbox"/>					
Ekstra lett lettmelk	<input type="checkbox"/>					
Skummet melk (søt/sur)	<input type="checkbox"/>					
Appelsinjuice	<input type="checkbox"/>					
Saft med sukker	<input type="checkbox"/>					
Saft kunstig søtet	<input type="checkbox"/>					
Brus med sukker	<input type="checkbox"/>					
Lett brus, kunstig søtet	<input type="checkbox"/>					

**16. Bruker du vanligvis margarin/smør på brodskriven?**  Ja  Nei

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