UNIVERSITY OF TROMSØ UIT

FACULTY OF HEALTH SCIENCES
DEPARTMENT OF COMMUNITY MEDICINE

Physical activity, osteoporosis and fracture risk

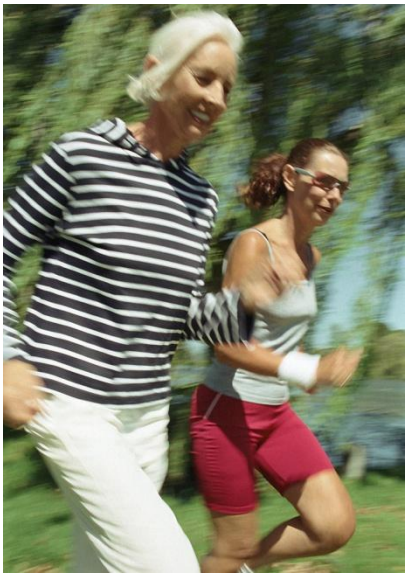
Long-Term Associations In A General Population

Bente Morseth

A dissertation for the degree of Philosophiae Doctor
June 2011

Physical activity, osteoporosis, and fracture risk

Long-term associations in a general population



Illustrasjonsfoto: colourbox.no

Bente Morseth

Tromsø 2011

Department of Community Medicine

Faculty of Health Sciences

University of Tromsø

The Research Council of Norway

Acknowledgements

This project was carried out at the Department of Community Medicine (ISM) with funding from the Research Council of Norway. In 2008, I was fortunate to be offered a position at ISM so that I could work with this project and proceed toward a PhD, and for that I am sincerely grateful. During my three years as a PhD candidate, I have enjoyed the inspiring work environment at ISM, and I greatly appreciate the support, input, and feedback from so many nice and competent co-workers.

I want to express my gratitude to my main supervisor, Lone Jørgensen, for all your input, feedback, clear answers and guidance. You are honest and supportive, your door is always open, and you always take the time needed to guide me. I am inspired by your work and knowledge, and your instant feedback and continuous support has been essential to me.

My warmest thanks to co-supervisor Nina Emaus for all the professional and social input throughout these years. Your enthusiasm and drive are truly inspiring, and your sincere interest has been of great importance to me. Your knowledge, contribution and commitment to osteoporosis are invaluable to me and others.

I am also sincerely grateful for the all the input and feedback from my other co-supervisor, Tom Wilsgaard – I greatly appreciate your always useful and reliable advice, not only on statistics, but on any subject. You have patiently guided me through the statistic and answered my novice statistical questions, even when you were really busy.

Bjarne K. Jacobsen, you were never formally my supervisor, but you have been there all the way as a 4th supervisor, with enthusiasm and vast knowledge, always giving more of your time than needed. Your eye for details, while at the same time keeping the general view, is impressing. I am sincerely grateful for your time, input, feedback and humorous reflections ☺.

Svanhild, I am grateful that I you have become my friend. We have had many interesting conversations and some exciting trips - there have been both serious times and a lot of fun! Jan-Magnus, thank you for creating a great work environment in the small office that we shared these three years, for useful discussions, but also good, quiet moments. Sanda, thank you for being my friend and for the nice evenings with food and work and long conversations about EPINOR stuff and everything else. Marit, I am grateful for the friendship that we have developed, for all your caring support and help, for being our dog radiologist, and for all the teamwork throughout the PhD courses. Anna-Sofia, we have shared good moments, fun moments – and some more difficult statistical moments, too!

Kjell-Arne, Marthe, Unni, Haakon, Nadine, and Morten, thank you for a pleasant time together in EPINOR. Thanks to Laila, Anita, Guri, Kristin, and my other colleagues at the Department of Community Medicine

for helpful discussions and for sharing your knowledge. I would particularly like to thank my other co-authors, Ragnar Joakimsen, Luai Ahmed, Åshild Bjørnerem, and Jan Størmer for useful input and valuable hints. A special thanks to Luai for providing me with information whenever needed, for knowledgeable input, and for your goodwill at any time. I would also like to thank Aina Emaus at Oslo University Hospital for your kindness to provide necessary information whenever needed.

I am also grateful for all the instant help that I have received from the technical and administrative support team at ISM, a special thanks to Mona Ingebrigtsen, Jarle Mathiassen, and Merete Albertsen – you really know how to get things done! I want to thank the Research Council of Norway for funding this project. Of course, this work could not be done without all of you who took the time to participate in the Tromsø Study.

Finally, I want to express my gratitude to my family. My mother, who introduced me to sport and physical activity when I was very young and provided me with a lifelong commitment to physical activity in many ways. My dear dad, who died from me so suddenly halfway through my PhD. Our loving dog Mumigrisen who we also lost. We miss you both deeply. Luckily, I am still greeted by two joyful dogs every time I return back home to Bodø. Håvard, my life companion, you made this possible by taking care of everything in my life so that I could concentrate on the PhD. You have made me food, taken care of the dogs, the house, the car, the bills – I am truly grateful for your selfless support and for always wanting the best for me.

Contents

Summary

Osteoporosis and related fractures are a major health problem among elderly people, and Norway has reportedly one of the highest fracture rates in the world. Many factors contribute to osteoporosis and fractures. One highly relevant protective factor is physical activity, which is a major mechanical determinant of the properties of the skeleton. Physical activity may postpone the age-related bone loss and decrease the risk of falling, and thereby reduce the risk of osteoporotic fractures.

Because osteoporosis and fractures primarily occur in the elderly, it is of interest to observe the long-term benefits of physical activity. The Tromsø Study, which is a population study with recurrent surveys, provides an excellent opportunity to follow people throughout adulthood into older age. Thus, the aim of this thesis was to examine the long-term associations between physical activity and outcomes such as bone mineral density (BMD) (paper II) and risk of non-vertebral fracture (paper III) in adults. Moreover, to form a basis for these associations, the stability (i.e. tracking) of physical activity habits over three decades was investigated (paper I). In all three papers, longitudinal data were derived from the surveys in the Tromsø Study. Adult women and men were followed throughout adulthood into older age.

Analyses of tracking of physical activity indicated that physical activity habits during adulthood are relatively stable (i.e. track) over time (paper I). Sedentary adults have markedly higher odds of being sedentary later in life than active adults. The same were true for the other physical activity levels, i.e. being physically active in adulthood is a strong predictor of being active later in life. The results from this study have implications for the subsequent studies in this thesis.

In paper II, examination of the associations between physical activity and BMD showed a positive linear trend in BMD across physical activity levels. The differences in BMD between physical activity groups were rather small, but consistent over different sites of the hip and forearm, and even small differences in BMD can have relatively large effects on fracture risk.

The results from paper III showed that moderate and high physical activity appeared protective against fractures in the weight-bearing (lower) skeleton, whereas the risk of fracture in the non-weight-bearing skeleton was not related to physical activity level, indicating that effects of physical activity on fracture risk are site-specific.

These population studies suggest that physical activity can prevent or delay osteoporosis and age-related fractures, and that the mechanisms partly involve bone mineral density, as physical activity was related to BMD in a dose-response pattern. Moreover, there is a tendency that physical activity habits in adults are fairly stable over a long time. This implies that adults who are sedentary tend to stay sedentary later in life, which may be worrying considering the many health benefits of physical activity.

Sammendrag

Osteoporose og osteoporotiske brudd utgjør et stort helseproblem blant eldre, og Norge har den høyeste forekomsten av hofte- og underarmsbrudd som er rapportert. Mange faktorer bidrar til osteoporose og brudd, deriblant lav fysisk aktivitet. Fysisk aktivitet er en viktig faktor for skjelettets mekaniske egenskaper og kan utsette det aldersrelaterte tapet av benmasse og redusere risikoen for å falle.

Osteoporotiske brudd oppstår hovedsakelig hos eldre, derfor er det av interesse å undersøke de langsiktige gevinstene av fysisk aktivitet. Tromsøundersøkelsen, som er en gjentatt helserelatert befolkningsundersøkelse, gjør det mulig å følge mennesker fra voksen til eldre alder. Målet med denne avhandlingen var å undersøke sammenhenger mellom fysisk aktivitet og bentetthet (artikkel II) og risiko for ikke-vertebrale brudd (artikkel III) over tid hos voksne. For å danne et grunnlag for analyse av disse sammenhengene, ble stabiliteten (dvs. "tracking") av fysiske aktivitetsvaner gjennom tre tiår utredet (artikkel I). I alle tre artiklene ble voksne kvinner og menn ble fulgt fra voksen til eldre alder, gjennom analyser av longitudinelle data fra Tromsøundersøkelsene.

Resultatene fra artikkel I viste at det fysiske aktivitetsnivået i voksen alder holder seg relativt stabilt over lang tid, inn i eldre år. Vi fant at voksne kvinner og menn som er fysisk aktive, har betydelig større sannsynlighet for å være aktive senere i livet enn de inaktive. På samme vis har de som er inaktive høy sannsynlighet for å være inaktive flere tiår senere. Resultatene fra denne studien dannet et grunnlag for de påfølgende studiene i denne avhandlingen.

Analysene i artikkel II viste at høy bentetthet var tydelig assosiert med høyt fysisk aktivitetsnivå. Den positive sammenhengen mellom fysisk aktivitet og bentetthet var konsekvent i hofte og underarm. Selv om forskjellene i bentetthet mellom ulike nivåer av fysisk aktivitet var relativt små, var de statistisk signifikante, og selv små forskjeller i bentetthet kan ha store effekter på risiko for benbrudd.

Analyser av bruddrisiko (artikkel III) viste at fysisk aktivitet beskytter mot brudd i det vektbærende skjelettet. Derimot var risiko for brudd i det ikke-vektbærende skjelett ikke relatert til fysisk aktivitetsnivå. Dette indikerer at effektene av fysisk aktivitet på bruddrisiko varierer med bruddsted.

Resultatene fra studiene i avhandlingen tyder på at fysisk aktivitet kan bidra til å forebygge osteoporose og aldersrelaterte brudd, og at dette delvis skjer via mekanismer som inkluderer bentetthet, ettersom vi har vist at fysisk aktivitet er positivt assosiert med bentetthet. Videre er det indikasjoner på at aktivitetsvaner i voksen alder har en tendens til å holde seg stabile over flere tiår. Dette medfører at voksne som er inaktive, har en tendens til å være inaktive også senere i livet, noe som er bekymringsfullt med tanke på at fysisk aktivitet har en rekke positive helseeffekter.

List of papers

The following papers are part of this thesis:

Paper I:

Morseth B, Jørgensen L, Emaus N, Jacobsen BK, Wilsgaard T. Tracking of leisure time physical activity during 28 yr in adults: The Tromsø Study. *Med Sci Sports Exerc* 2011;43(7):1229-1234.

Paper II:

Morseth B, Emaus N, Wilsgaard T, Jacobsen BK, Jørgensen L. Leisure time physical activity in adulthood is positively associated with bone mineral density 22 years later. The Tromsø study. *Eur J Epidemiol* 2010;25(5):325-331.

Paper III:

Morseth B, Ahmed LA, Bjørnerem Å, Emaus N, Jacobsen BK, Joakimsen R, Størmer J, Wilsgaard T, Jørgensen L. Leisure time physical activity and risk of non-vertebral fracture in women and men aged 55 years and older: The Tromsø Study. *[Submitted]*

Abbreviations

BMD: bone mineral density

BMI: body mass index

CI: confidence interval

DXA: dual-energy X-ray absorptiometry

GEE: generalized estimating equations

HR: hazard ratio

IPAQ: international physical activity questionnaire

MET: metabolic equivalent

MRI: magnetic resonance imaging

NHANES: National Health and Nutrition Examination Survey

OR: odds ratio

pQCT: peripheral quantitative computed tomography

RCT: randomized controlled trial

RR: relative risk

SD: standard deviation

SPSS: Statistical Package for Social Sciences

SXA: single-energy X-ray absorptiometry

UNN: University Hospital of North Norway (Universitetssykehuset Nord-Norge)

VO_{2max}: maximal oxygen uptake

WHO: World Health Organization

1 Background

1.1 Epidemiology of osteoporosis and fractures

1.1.1 The burden of osteoporosis and related fractures

Osteoporosis is defined as "a systemic skeletal disease characterized by low bone mass and microarchitectural deterioration of bone tissue, with a consequent increase in bone fragility and susceptibility to fracture"[41]. Osteoporosis constitutes a considerable public health concern, estimated to affect 75 million people in the United States, Europe and Japan together[56]. Although osteoporosis traditionally has been considered a female disorder, approximately one in four individuals with osteoporosis is a man[120]. Bone loss increases with advancing age[60, 63, 71], and the prevalence of osteoporosis measured at the femoral neck has been shown to increase from 20% at the age of 65 to more than 40% at the age of 80 years in women[63]. An even higher increase has been measured at the forearm, resulting in a prevalence of osteoporosis of 66% in women and 31% in men after the age of 70[71]. Several estimates indicate a rapid increasing prevalence of osteoporosis[35], and the increasing elderly population[278] will further augment the number of people with low bone mass or osteoporosis in the future.

Accordingly, osteoporotic fractures, the clinical outcome of osteoporosis, arise as one of the major health care problems, particularly among elderly people[108], and Norway has the highest reported fracture incidence in the world[166]. Fractures lead to substantial disability, morbidity, and reduced quality of life, as well as increased mortality, in the elderly[39, 70, 108, 265, 269]. According to a recent meta-analysis, excess mortality (over and above mortality rates in control populations) the first year after a hip fracture ranges from 8% to 36%[1]. In a Swedish study[228], 50% of the hip fracture patients never recovered to their pre-fracture health status regarding ability to walk and home care needs. The high burden of fracture generates tremendous medical costs for society, illustrated by various estimates, particularly associated with hip fractures[35, 39, 211]. Recent estimates from 2011 indicate that the costs of fragility fractures in six European countries amount to 31 billion Euro[239].

1.1.2 Fracture incidence and lifetime risk

In 2000, the total number of new fractures worldwide was estimated to 9.0 million, including 1.6 million hip fractures, 1.7 million forearm fractures, and 1.4 million clinical vertebral fractures[108]. However, fracture incidences vary up to tenfold between populations[120]. The incidence is higher in Scandinavia than in North America, while fracture rates are lower in Asia and Latin America[39, 108, 269]. In Oslo, Norway, the annual age-adjusted incidence of hip fracture in the age group ⩾50 years has been estimated to 12

per 1000 inhabitants for women and 4.5 in men during the 1980's and 90's[65, 166]. Recent estimates from Harstad, Northern Norway, are somewhat lower[62]. The reason for the high incidences of hip and forearm fractures in Norway is not clear, and research reports have failed to link the incidence differences to cold climate[166]. Moreover, the incidence of fracture is generally higher in urban than in rural areas[39, 65, 182, 203, 240].

The absolute risk for an osteoporotic fracture, in terms of lifetime risk at age 50 years, is estimated to 39-53% in women and 13-22% in men in UK, Sweden, Australia, and US[107]. In the Tromsø population, the comparable lifetime risk was recently reported to be 55% in women and 25% in men[2]. Thus, in Tromsø more than one of two women and one of four men aged 50 years are expected to experience a fracture during their remaining lifetime. The lifetime risk for wrist fracture is lower; in UK women 16%, however declining with age, whereas the lifetime risk in men is low (3%)[262]. Recent research indicates that the increasing trend in hip fractures observed in the past decades may recently have leveled off, of reasons still not known[39, 124].

Box 1: Epidemiology of hip and wrist fractures

Hip fractures

- Hip fractures are more severe than other fractures and lead to mortality, more severe disability and consequently higher costs[43]
- The majority of all hip fractures are the result of a simple fall from standing position[43]
- The majority of hip fractures are osteoporotic[268]
- 30% of all hip fractures occur in men[202]

Wrist fractures

- Wrist fractures occur mainly in women[39]
- Whereas the incidences of hip fracture increase with age[85], wrist fracture incidence in women increase from 45 to 60 years, then levels off[39, 107]
- The lifetime risk of wrist fracture in women declines from age 50 to 70 years[262]
- The incidence in men continues to stay low with advancing age[262]

1.2 Bone strength

Whole-bone strength, which determines the ability for a bone to bear load and resist fracture, is affected by biological mechanisms, which produce changes in bone properties (remodeling), as well as physical aspects[32, 78].

Physical bone strength depends on the structural and material properties of bone[4, 29, 31, 33, 42, 78, 269], including:

- Bone mass
- Bone mineral density (BMD)
- Bone size
- Geometry/shape/macroarchitecture of the bone (spatial distribution of the bone mass)
- Microarchitecture of the bone, including
    - trabecular thickness, orientation, and connectivity
    - cortical thickness/mineral content and porosity
    - microcracks/microdamage
- The quality of bone matrix
- The degree of mineralization.

1.2.1 Bone mineral density (BMD)

There are various imaging techniques available for measuring bone strength, such as peripheral quantitative computed tomography (pQCT), high resolution magnetic resonance imaging (MRI), and finite element analysis[30, 32]. However, the gold standard for diagnosis of osteoporosis is considered to be dual-energy X-ray absorptiometry (DXA)[42].

DXA measures areal BMD (g/cm^2), i.e. the ratio between bone mineral content and the scanned area[42]. DXA is based on quantification of the amount of X-ray energy that is absorbed by the mineralized bone mass (i.e. hydroxyapatite, which is the most important inorganic component of bone). Single-energy X-ray absorptiometry (SXA) is based on the same principles, although the measures must be done under water, thus it is only available for the forearm and heel. DXA and SXA are the most feasible and available instruments to express bone strength in humans, consequently the diagnosis of osteoporosis is based on areal BMD[277].

1.2.2 The role of BMD in osteoporosis

The definition of osteoporosis incorporates both low bone mass and microarchitectural deterioration of the bone tissue[41]. As microarchitectural deterioration and other indicators of bone strength are not easily measureable with present non-invasive methods[4, 29, 269], the diagnosis of osteoporosis is based on BMD measurements. In 1994, WHO provided a diagnostic definition of osteoporosis in women as bone mineral density (BMD, g/cm^2) more than 2.5 standard deviations (SD) below the young female adult mean BMD[277] (table 1). Later, these criteria have been specified by introducing the femoral neck as the preferred reference site and by recommending the Third National Health and Nutrition Examination Survey (NHANES III) data for white women in the age range 20-29 years as the young normal reference range[116, 122]. Diagnostic criteria for men have not been well established, as men were not included in the 1994 WHO criteria, but it is now recommended that the reference range for BMD in young adult women also be used for the diagnosis of osteoporosis in men[119, 122]. This view is based on results showing that the risk of hip fracture at a given absolute BMD value is independent of sex[122].

Recently, there has been focus on incorporating other risk factors in addition to BMD, by expressing the absolute fracture risk (the probability of fracture within a given time period)[121].

Table 1: Diagnostic thresholds for osteoporosis[277]

Definition	BMD values in relation to the mean value of peak bone mass in young normal women*
Normal	Not more than 1 SD below the mean
Osteopenia	Within -1 SD and -2.5 SD the mean
Osteoporosis	More than 2.5 SD below the mean
Severe osteoporosis	More than 2.5 SD below the mean and the presence of fractures the mean

*When BMD is measured in relation to the young female adult mean, one SD unit is equal to a T score of 1. When BMD is expressed in relation to the age- and sex-matched mean, one SD is equal to a Z score of 1[271].

1.2.3 BMD as a predictor of fracture risk

The use of BMD in diagnosing osteoporosis is based on the strong association between BMD and fracture risk[192, 269]. Many studies have shown that risk of fracture increases with decreasing BMD, summarized in previous meta-analyses[109, 171]. Laboratory studies have demonstrated a high correlation between BMD and the force that is required to break a bone[42], and it is indicated that BMD predicts 50-85% of the variation in bone strength[4, 29, 192]. The relationship between bone strength and BMD is non-linear, which means that small changes in BMD can lead to large changes in bone strength and fracture risk[29]. Thus, BMD is one of the major predictors of fracture risk[118, 171].

Existing studies report fairly similar gradients of risk for fracture (i.e. the relative risk for each SD decrease in BMD)[109]. The risk gradient varies with the site of BMD measurement and the fracture site at risk[122]. When BMD is measured at the hip, hip fracture risk generally increases with a relative risk (RR) of 2.6 per SD decrease in BMD, whereas RR of other fractures increases 1.6 times per SD[109, 171]. Although fractures are best predicted by site-specific BMD measurements[122], BMD measured at other sites such as the spine, distal radius, or calcaneus indicate a RR of any fracture of 1.5 per SD decrease in BMD[42]. A Z-score of -2.5 thus means that the fracture risk is almost 9-fold higher ($2.6^{2.5}$) than compared with a Z score of 0[122].

1.3 Pathophysiology of osteoporosis and fractures

1.3.1 Remodeling

Bone is a dynamic and highly metabolic tissue that is renewed during adulthood by continuous bone remodeling, so that in one year, 1-10% of the skeleton is exchanged. Remodeling involves bone resorption and formation, a continuous process by which bone cells remove and replace bone tissue in cycles of 3-5 months[88]. The bone cells responsible are osteoblasts and osteoclasts, which together form the "basic multicellular unit"[217]. Osteoclasts remove bone on the surface and create a cavity, and after a delay, osteoblasts produce new bone that fills the cavities[29]. The net result of bone formation and resorption determines the mass, size, shape, and architecture of the bone[226].

Cortical bone is the outer, dense part of bones, amounting to 80% of the bone mass, whereas trabecular bone is cancellous and fills the interior of the bone where it forms a net of trabeculae[88]. The open net of trabeculae allows interaction with blood vessels, bone marrow, and connective tissue. Consequently the metabolic activity in trabecular bone is many times faster than in cortical bone. Remodeling can occur at different surfaces; the periosteum (the outer surface, covering cortical bone) and the endosteum (inner surface) which comprises the endocortical, trabecular, and intracortical (Haversian) surfaces[217, 226].

1.3.2 Pathophysiology of bone loss

Bone mass accumulates during childhood and adolescence, and peak bone mass is reached in the twenties at most sites[90]. After bone mass has reached a peak in young adulthood, a gradual bone loss begins, possibly in the third or fourth decade[61, 274]. In women, bone loss accelerates during menopause, probably because of reduced estrogen levels (which lead to increased resorption and turnover), whereas men lose bone gradually[226, 227]. From the age of 20 to 70 years, both women and men may lose a considerable amount of bone mass. At the hip, as much as 25-40% in women and 20-35% in men of the peak bone mass may be lost[41, 178, 274]. In elderly women and men, hip BMD may annually decrease 1.0-1.5% in women and 0.5-1.0% in men[24, 60, 110, 135]. At the forearm, it has been shown that BMD is stable up

to the age of 50 years in women, followed by a strong decline thereafter[71]. In men, BMD starts to decline at the age of 40, and after age 65, the decline in forearm BMD is similar in women and men.

Osteoporosis may be a consequence of low bone mass gain during growth (resulting in low peak bone mass), insufficient maintenance of bone mass in adulthood, or excessive bone loss during late adulthood. The relative importance of bone mass increase during growth and peak bone mass in osteoporosis prevention at old ages is not yet thoroughly known. Some studies have indicated that bone mass gain in early years may not persist[79], emphasizing the role of preservation of bone mass during adulthood and elderly years.

As mentioned, an imbalance in the remodeling process during adulthood may lead to osteoporosis[217]. During adulthood, bone formation and resorption should ideally be in balance, preserving net bone mass. With advancing age and in situations with abnormal remodeling, bone resorption exceeds bone formation, creating a surplus of resorption cavities and net bone loss[29]. The net bone loss is a result of the trabeculae becoming thinner and detached, and cortical bone becoming thinner and porous, even though the periosteal bone formation increases with aging[226].

1.3.3 Biomechanics of bone loading

Bones are built to be both strong and lightweight, which is accomplished by specific material and structural properties. Bone consists of organic material (mainly collagen) and inorganic matrix (mainly hydroxyapatite which is a mineral composed of calcium and phosphate)[88]. Due to the flexible collagen, bone can allow elastic deformation of the bone (strain) during loading by storing energy[226]. A load that is applied to bone is called stress, defined as force divided by area[251]. The applied load causes a mechanical deformation of bone tissue, and this deformation can be measured as strain[113, 235]. Strain is the ratio of the amount of shortening divided by the original length, typically expressed as microstrain, 10^{-6} (i.e. a bone of length 500 mm experiencing 0.5 mm deformation gives a strain of 0.001 or 0.1%, equal to 1000 microstrain)[235]. Strains may be compressive, tensile (when the bone stretched), or torsional (shear) (when the bone is twisted), and in most situations, they affect bone in a combined way[235, 251], i.e. a deformation can create 2500 microstrain in compression on the concave side of a bending diaphysis, while creating 2000 microstrain in tension on the other side[113].

At whole bone level, the relationship between load and deformation is represented by the stress-strain curve. The slope of the stress-strain curve is called Young's modulus (strain = stress/Young's modulus)[143]. The yield point is the point on the slope where the deformation is beyond its elasticity. Deformation beyond the yield point will therefore lead to permanent deformation and eventually fracture.

1.3.4 Pathophysiology of fractures

When the energy from the applied load exceeds the capacity of the bone to absorb that energy, a fracture occurs. Thus, both extrinsic and intrinsic factors affect the occurrence of a fracture[231]. For hip fractures, extrinsic factors that affect the applied load are primarily falls, as in the elderly, more than 90% of all hip fractures are caused by a fall, and magnitude and direction of applied load may be crucial. Intrinsic factors that affect bone strength are described in chapter 1.2.

1.4 Risk factors for osteoporosis and fracture

In elderly people, low BMD (osteoporosis) and falling are the two main risk factors of fracture[125]. Genetic factors explain 50%-80% of the variation in BMD[215]. However, fracture risk is also affected by many other factors, as shown in table 2.

Table 2: Risk factors for osteoporotic fractures

Clinical characteristics and medical history	Bone strength related
Genetic factors[269]	Low BMD[117, 269]
Advancing age[39, 83, 117, 269]	Bone architecture and geometry[269]
Female gender[117]	High bone turnover[117, 269]
Asian or Caucasian[55, 83, 117]	Microdamage accumulation in bone[269]
Low weight/body mass index (BMI <18.5 kg/m^2)[83, 120]	Degree of mineralization of bone[269]
Weight loss (>10%)[202, 269]	
Height[269]	**Fall related**
Family history of hip fracture[39, 83, 117, 120]	Muscular weakness[269]
Prior fragility fracture[39, 83, 117, 269]	Impaired functional mobility[269]
Low dietary calcium intake/absorption[55, 83, 117]	Neuromuscular disorders[117, 269]
Vitamin D deficiency[55, 83, 117]	Visual impairment[117, 269]
Medications[83, 269]	Cognitive impairment[269]
Estrogen exposure[269]	Impaired proprioception[269]
Premature menopause[39, 83, 117]	Increased postural sway[269]
Amenorrhea[117]	Season[269]
Hyperparathyroidism[55, 83]	
Low serum testosterone levels[55, 202]	**Lifestyle related**
Poor health/comorbidity[83]	Cigarette smoking[83, 117, 120]
	Physical inactivity[55, 83, 117, 269]
	Excessive alcohol consumption[83, 117]

1.5 Prevention of osteoporosis and fractures: Physical activity

The high fracture incidences and the serious outcomes of fractures call for knowledge about effective preventive strategies that are feasible for most people[134]. The main non-pharmacological interventions for fracture reduction include prevention of osteoporosis and prevention of falling[125], accentuating physical activity as an important key factor. Physical activity may increase peak bone mass and postpone the age-related bone loss through mechanical mechanisms, and also increase muscle strength, neuromuscular functions and balance, and thus reduce the risk of falling[17, 134].

1.5.1 Physical activity

The Norwegian recommendations for physical activity aimed at health promotion state that adults *should be physically active at least 30 minutes, preferably every day. The intensity should be at least moderate, as in fast walk. By increasing the duration or intensity, additional health benefits can be gained*[14]. These recommendations are based on research of associations between physical activity and morbidity and mortality[14]. Physical inactivity is a known risk factor for many diseases, such as cardiovascular diseases[147, 205], type 2 diabetes mellitus[3], obesity[51], and some types of cancer[246]. Physical inactivity also affects bone mass. This became apparent in the 1960's when space flight studies found loss of BMD in astronauts[263]. Because astronauts in space are subject to weightlessness due to microgravity, the loads on bone from gravitation and muscle contractions are minimal. Bone loss during microgravity has been confirmed in many studies, showing severe loss of both trabecular and cortical bone mass in astronauts attending long-duration space flights[142, 154, 155]. These findings agree with studies of long-term bed rest[159, 160, 282]. Since then, a vast number of studies have examined the association between physical activity and bone health. Yet, there are many contradictory findings and unsolved issues[22], partially because of the challenges associated with assessment of physical activity and the diversity of physical activity behavior.

1.5.2 Mechanical loading

According to the prevailing theory, the effects of physical activity on BMD are linked to the mechanisms of mechanical loading[230, 281]. In 1892, Wolff[77] stated that bone tissue accommodates to stress that is imposed on it, and later research on the topic has been founded on this contention. Several theories have been proposed to explain the loading mechanism, and one of the most recognized is the "Mechanostat theory" by Harold Frost[75, 76].

The mechanostat theory. Frost proposed that local deformation from mechanical loading stimulates bone cells, resulting in bone adaptation[75, 76]. The mechanostat theory indicates that there is a lower and an upper strain threshold, creating a range where strain stimuli maintains homeostasis of the remodeling process and bone mass, called the physiological loading zone. Below the lower threshold (<200 microstrain), called the "minimum effective strain for remodeling", the stimuli is insufficient to maintain

formation, and resorption will be the overriding process, resulting in bone loss. Above the upper threshold (2000 microstrain, the "minimum effective strain for modeling"), formation is dominant, resulting in bone gain. These thresholds may be relative to the individual's habitual loads[235]. Systemic and local biochemical factors, age, sex, and genes probably influence the bone cells' sensitivity to mechanical stimuli[234]. Hormones influencing remodeling are mainly vitamin D, parathyroid hormone, estrogen, and calcitonin[88].

The mechanostat theory relies mainly on the *magnitude* of the strain as the important driving force for bone remodeling[113]. However, an increase in *frequency*, not only magnitude, may represent overload and bone formation[113, 235]. Moreover, several animal studies have demonstrated that *dynamic*, but not static strains (whereby strain rate = 0), induce bone formation[157, 222, 253], implying that the activity should be dynamic, not static. *Uneven distribution* of the strain seems to have a higher potential for increasing osteogenesis than the habitual loading pattern[67, 114], indicating that the intensity of the activity should be increased or changed beyond the habitual level. Moreover, after *a few loading cycles*, the adaptive response decreases [222, 256], indicating that duration is of less importance. Finally, inserting a *rest period* after each loading cycle can increase the osteogenic response [218].

Box 2: Osteogenic activities

Mechanical characteristics of osteogenic activities

- **High-impact**
- **Dynamic**
- **Varying and increasing loads**
- **A few loading cycles seem sufficient**

Mechanotransduction. The cellular mechanism responsible for conversion of a mechanical force into a cellular response is called mechanotransduction[225]. In recent years, animal studies have been focusing on osteocytes as mechanosensors, because of their suitable location[27, 235, 279]. Osteocytes constitute the majority of bone cells and are scattered throughout the bone matrix where they are found in lacunae, connected to each other and to lining cells at the trabecular surface by a network of canaliculi[36, 156]. Osteocytes are assumed to detect load applied by external forces (mechanical strain) and to transduce signals to the cells on the surface, where remodeling (resorption and formation) occurs[254]. Several mechanisms have been proposed for the activation of osteocytes[243], and recently, fluid flow-induced shear stress has been acknowledged as the most essential mechanism[212, 252]. The molecular mechanisms within osteocytes that transduce the mechanical signal into a biochemical signal are not fully understood, but may include ion channels, integrins, and the cytoskeleton[38, 254]. The communication

between the sensor cells (osteocytes) and the effector cells (osteoblasts and osteoclasts) involve direct cell–to-cell contact and autocrine and paracrine signals[38]. Within 48 hours, osteoblasts respond with bone formation and new osteoblasts and osteoclasts are recruited to the bone surface[38, 235, 254].

1.5.3 Fall prevention

Falling is very common among the elderly and the tendency to fall increases with age. A fall seems to be the strongest single risk factor for a fracture, as 90% of all hip fractures occur from a fall; moreover, the nature of the fall is a critical determinant for fracture[37, 125]. Thus, in order to prevent fractures, it is important to prevent falls. The risk of falling is affected by age-related changes in muscle strength, which declines up to 50% from the age of 30 to 80 years[45], and impaired balance and gait pattern[45]. Physical activity may improve physiological skills and thereby reduce the risk of falling[133]. Muscle strength has been shown to increase up to 200% even in old people, and the skeletal muscles seem very adaptive to training even at old ages[45]. Balance may also be improved by balance and strength training, although not consistently.

1.6 Rationale for the thesis

Because a fracture often has serious consequences, it would be favorable to call attention to preventive efforts. Physical activity is a feasible non-pharmacological approach that may delay bone loss and prevent falls. Nevertheless, a limited number of studies has examined physical activity and fracture incidence[185], and recent studies substantiate inconsistent findings[9, 195].

Because BMD is a central component of osteoporosis, bone strength, and fracture risk, the association with physical activity is of great interest. Although a large number of short-term studies demonstrate a positive association between physical activity and BMD[17, 84], fragility fractures are far more common in the elderly, whereas the bone mass benefits of physical activity seem more pronounced and consistent at younger age[126]. Therefore, the long-term associations between physical activity and BMD at older ages are of interest.

Epidemiological studies typically assess physical activity with a single or few questions and the ability to assess changes in physical activity habits is often limited. Physical activity levels will most likely change during the follow-up period, while at the same time, most epidemiological studies are restricted to one measurement of physical activity, usually at baseline. Changes may affect the outcome of epidemiological studies; therefore, it is essential to gain knowledge about physical activity habits throughout the adult life.

2 Aims

The general objective of these cohort studies was to examine the associations between physical activity in adulthood and BMD and non-vertebral fractures at older age. When studying long-term associations, an important factor to consider is changes in physical activity level over time. Therefore, an additional aim was to describe the degree of stability (tracking) of physical activity in the population over the last three decades.

The specific aims were to examine:

1. Tracking of physical activity in adult women and men over three decades.

2. Associations between leisure time physical activity and BMD later in life in adult women and men.

3. Associations between leisure time physical activity levels in adulthood and risk of non-vertebral fracture in women and men.

3 Knowledge status

This chapter presents the knowledge status prior to each of the three studies, which were submitted in February 2010 (Paper II), July 2010 (Paper I), and March 2011 (Paper III).

3.1 Tracking of physical activity

Nordic Health Authorities recommend at least 30 minutes physical activity with moderate intensity most days of the week, and similar recommendations are given in other countries[89]. Yet, in most countries, less than 50% of the population meet the national recommendations[100, 232]. Development of targeted strategies that encourage physical activity necessitates knowledge of stability, or tracking, of physical activity over time, but the degree of stability of long-term physical activity habits is not very well known. Furthermore, in most epidemiological health studies, assessment of physical activity has to be confined, due to competing resources.

Stability, or tracking, of a characteristic is commonly defined as 1) maintenance of relative rank or position over time or 2) predictability of later values from earlier measurements[13, 255, 275]. To estimate tracking or stability, correlation between repeated measures is the most frequent effect measure[273]. Only a few research groups have examined tracking of physical activity through adulthood. Studies from the United States[5, 162, 223], Belgium[48, 163], Canada[72] and Finland[144, 242] report low to moderate tracking of physical activity, with correlation coefficients approximate to 0.30 in most studies. Few studies have examined prediction of physical activity from earlier measurements[144, 177, 242, 249], and the majority of these investigated the time span from adolescence to adulthood[177, 242, 249]. Kirjonen et al.[144] found that level of physical activity in adulthood was a strong predictor of physical activity level 5-28 years later.

3.2 Long-term associations between physical activity and BMD

Physical activity may prevent or delay osteoporosis by increasing peak bone mass during growth and early adulthood and reduce bone loss later in life, as shown i Figure 1.

Timing of exercise to reduce osteoporosis and related fractures:

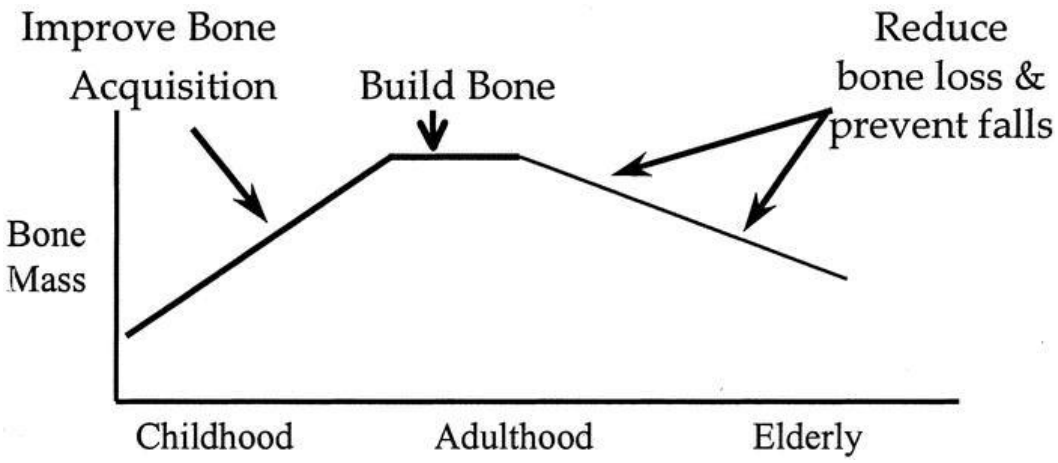


Figure 1. Exercise effects to reduce osteoporosis and fractures during life. Reprinted with permission ©Wolters Kluwer/Lippincott, Williams & Wilkins. *Beck BR, Snow CM. Bone health across the lifespan--exercising our options. Exerc. Sport Sci. Rev. 2003;31(3):117-122.*[22]

3.2.1 General effects of physical activity on BMD

Unilateral and cross-sectional studies. Data from numerous cross-sectional studies have demonstrated a positive association between physical activity and BMD[17, 22, 146]. Cross-sectional studies have typically compared athletes in various sports with sedentary controls. They report that athletes in a large range of high-impact sports have higher BMD than sedentary controls[23, 53, 67, 92, 129, 189, 197, 280]. Endurance activities seem to be beneficial to a certain degree, whereas low-impact activities such as swimming and cycling are associated with similar or lower BMD than controls. For example Nikander et al.[197] compared femoral neck BMD in premenopausal female athletes who competed in sports with different types of load. Athletes competing in high-impact sports (volleyball, hurdling, squash-playing, soccer, speed skating, step-aerobics) had the highest femoral neck BMD, followed by weight-lifters, thereafter orienteering and skiing athletes, while swimmers and cyclists had BMD similar to the non-athletes[197].

However, cross-sectional studies mainly include young, athletic participants, and genetics cannot be ruled out as an explanation. Studies of the effect of unilateral loading on bone mass allow for control of the role of genetics, and these studies consistently show that in tennis players, the dominant arm has thicker cortices and up to 22% higher BMD than the non-dominant arm[18, 96, 98, 99, 111, 123].

Children/adolescence. The most consistent evidence of the effects of physical activity and exercise on BMD is found in intervention studies of pre- and peripubertal children. Both high-impact physical activity[73, 169, 179, 187, 201, 260] and regular physical activity[86, 164, 165] during growth has been shown to increase BMD in active boys and girls compared with more sedentary children. A review of randomized controlled trials (RCTs) showed that BMD after 6 months increased 1-5% prepubertal and early pubertal children, and 0-2% in pubertal adolescents, compared with controls[94].

Premenopausal women. In adults, the effects of physical activity on BMD are smaller and less consistent. Findings from intervention studies indicate that exercising premenopausal women continue to increase bone mass compared to non-exercising controls[19, 20, 52, 74, 91, 167, 236, 259, 266, 276]. A review of intervention studies including premenopausal women concluded that impact activity may increase site-specific BMD by 1-3% compared with controls[247].

Postmenopausal women. In postmenopausal women, many intervention studies have been undertaken, in addition to several meta-analyses and systematic reviews. Two reviews indicate that aerobic and impact physical activity may slow down the rate of bone loss at the femoral neck by approximately 1 % per year[266, 276]. Other reviews confirm that aerobic exercise may slow down the loss of bone mass[136, 137]. Moreover, there is evidence of an effect of walking on the femoral neck BMD in postmenopausal women[26, 174, 229]. A recent review showed that both low-impact activity (including jogging) and high-impact combined with resistance training may reduce bone loss at the hip[175]. In contrast, one review failed to show any effects of various exercise on femoral neck BMD[138].

Elderly men. The results seen in women are also present in men[139, 191], although fewer studies have been conducted.

Type of activity. During physical activity, mechanical forces that act on bone are generated from two sources; loads from impact with the ground due to gravity (ground-reaction forces or impact forces) and loads from skeletal muscle contractions (muscle forces or no-impact forces)[112, 145, 250]. *Impact activities* are weight-bearing (e.g. jumping)[145]. However, most impact activities also involve muscle forces, and the individual effect of the ground-reaction forces can be difficult to separate[112, 145]. Impact activities primarily involve the lower skeleton. In contrast, *no-impact activities* influence bone mostly through muscle loading. No-impact activities can be weight-bearing (e.g. weight lifting) or weight-supported (e.g. swimming, cycling)[112, 145]. A few studies, mainly of post-menopausal women, have examined the effects of the type of activity in relation to BMD and very few studies in relation to fracture. Recent meta-analyses by Martyn-St James and Carroll[172, 173, 174, 175, 176] studied the effect of different exercise types on BMD in pre- and postmenopausal women. Resistance training alone increased lumbar spine BMD, but not femoral neck BMD[172, 173, 176], whereas combining impact activities with resistance training significantly increased BMD at both sites[175, 176]. In postmenopausal women, low-impact exercise (jogging combined with stair climbing and walking) also increased BMD at the lumbar spine and femoral neck[175], but not

walking alone[174]. These meta-analyses suggest that impact forces of a certain magnitude and rate, but not resistance training, were sufficient to increase femoral neck BMD, and that resistance training has strongest effect on lumbar spine BMD. However, in other studies, no-impact resistance training have been found to increase or preserve femoral neck BMD in postmenopausal women[193] and elderly men[181], emphasizing the inconsistency of the findings.

3.2.2 Long-term effects of physical activity

Although data from numerous cross-sectional and short-term prospective studies have shown a positive effect of physical activity on BMD at all ages, benefits of physical activity on BMD seem to be more pronounced and consistent during growth than in adulthood[17, 22, 146], whereas risk of fracture is substantially higher in old age[271]. Therefore, any long-term influence of lifetime physical activity on BMD at ages when osteoporotic fractures are more frequent would be of interest.

Sustained benefits of physical activity on BMD from childhood into young adulthood could result in a higher peak bone mass. Some studies have demonstrated that physical activity in childhood and adolescence predicts BMD levels in young adulthood, but the results are somewhat inconsistent[16, 50, 69, 141, 180, 199, 261]. Whether these BMD benefits are sustained to older ages is unknown. A high peak BMD may be beneficial later in life, but the effect of a high BMD in young adulthood is not yet clarified, and some evidence suggest that peak bone mass does not determine bone mass later in life[79]. The homeostatic system controlling bone mass is influenced by genetics, mechanical loading, and other lifestyle factors[79], and physical activity and mechanical loading during adulthood may be important factors determining bone mass later in life. Although the magnitude of the BMD benefits of physical activity in adults seems to be small, if bone loss could be reduced over a long time, this may be favorable for fracture risk at older ages.

Intervention studies and observational studies of physical activity effects are typically small and short-term, and only a few prospective, population-based studies can give insight to this issue[12, 46]. Thus, most studies that could give insight to long-term effects of physical activity are cross-sectional and case-control (retrospective), asking about past physical activity or comparing former athletes with controls[54, 64, 81, 101, 127, 130, 131, 148, 150, 198, 213, 258]. Former athletes seem to maintain higher BMD for 10-20 years after cessation compared to controls[54, 64, 127, 130, 131, 209, 258], and even up to 40 years after retirement[168], although most studies indicate that the benefits are lost after 30-40 years[127, 128, 129, 130]. Retrospective studies of lifetime physical activity have shown significant associations[101, 198] or no association between adulthood physical activity and BMD at older ages[34, 81, 150, 213].

3.3 Physical activity and risk of fracture

Physical activity may postpone the age-related decline in BMD and increase muscle strength and balance[17, 132], and thereby reduce the risk of fracture, but existing knowledge is limited by inconsistent results, few studies of fractures other than hip, and an almost complete lack of RCTs.

The observational studies have mainly examined hip fractures, mostly reporting that physical activity is associated with a lower risk of hip fracture[11, 44, 66, 68, 82, 151, 183, 184, 206, 216, 248], although in men, some studies report a non-significant lower fracture risk[97, 170, 190, 272]. Most case-control studies support an association between past physical activity and hip fracture incidence. Fewer studies include forearm fractures, and some studies report a higher risk of forearm fracture with higher physical activity[102, 140, 214], although other studies have found lower[244] or no significant fracture risk[82, 95, 194] with higher physical activity levels. A recent study of any osteoporotic fracture showed that leisure time physical activity was non-significantly inversely associated with overall fracture risk[186]. In contrast, results from two studies including all fracture types indicate that physical activity[9] and walking[195] can increase the fracture risk.

There are very few RCTs of exercise and non-vertebral fracture incidence[264]. One RCT lasting 30 months, examining the effects of jumping and balance exercises in elderly women, reported a reduced risk of fracture (any) in the exercise group compared with controls, but as the authors recognize, the sample size was too small to draw conclusions about fractures[149].

In a recent review, Moayyeri[185] suggests that physical activity may have different effects on different sites of fracture. However, very few studies of physical activity and fracture have focused on effects at various fractures sites. In 1998, Joakimsen et al.[105] examined physical activity in the second and third Tromsø Study in relation to non-vertebral fracture risk at various skeletal sites. In physically active women and men >45 years, the risk of fracture in the weight-bearing skeleton was lower (women non-significantly) than in sedentary subjects. In contrast, there was no reduction in risk of fracture in the non-weight-bearing skeleton among physically active compared with sedentary subjects.

4 Study population and methods

4.1 The Tromsø Study cohort

The Tromsø Study is a population-based health study, conducted in the municipality of Tromsø[103]. Presently, the study design encompasses six periodic health surveys, starting in 1974, followed by repeated surveys in 1979–80, 1986–87, 1994–95, 2001-02, and 2007–08. Total birth cohorts and additional random samples of inhabitants of the municipality of Tromsø, Norway, were invited to the surveys by written invitations sent by mail. The participation rate ranged from 65% to 77% (Table 3, chapter 6.2). All three papers are based on data from the Tromsø Study as shown in Figure 2. The Tromsø 1 population was not included in any of the three studies in this thesis because only men were invited.

Ethics

The Tromsø Study was approved by the Norwegian Data Inspectorate and recommended by the Regional Committee of Research Ethics. In Tromsø 4, 5, and 6, each participant signed a written informed consent.

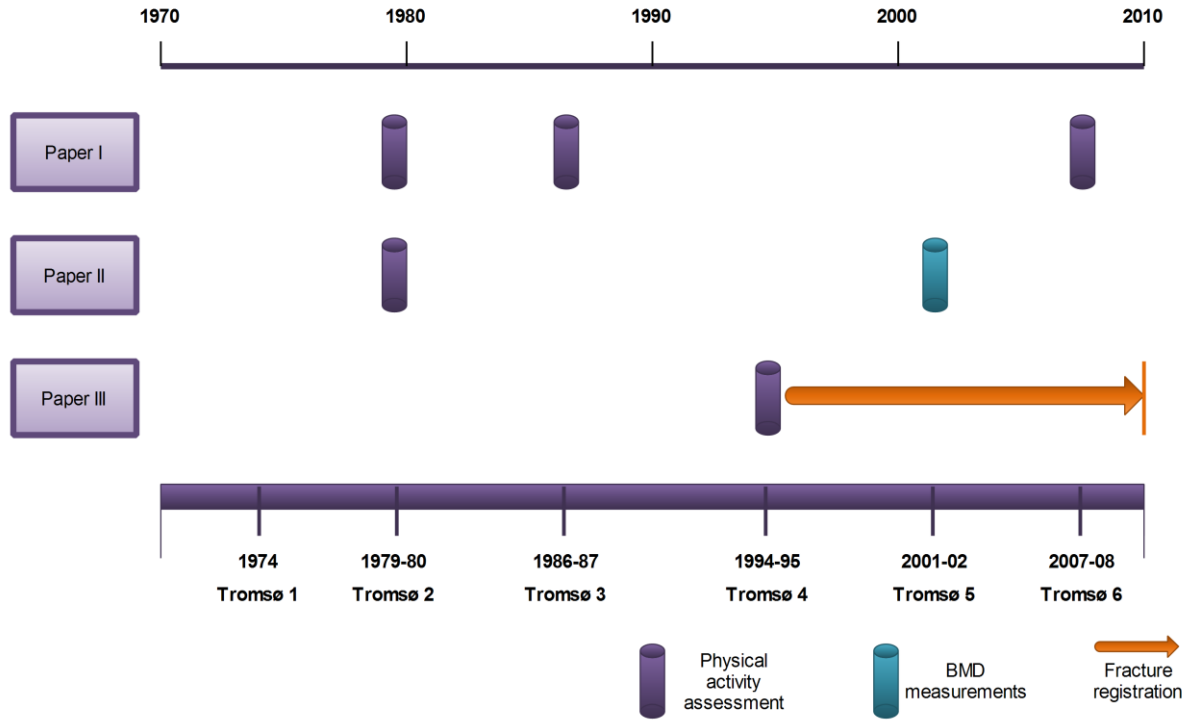


Figure 2. Design of the studies in the thesis.

Paper I study population

Paper I is a longitudinal tracking study of a cohort of men and women who participated in three of the six surveys in the Tromsø Study during the last three decades. We included subjects from the second survey in 1979–80 who had repeated measures in the third survey in 1986–87 and the sixth survey in 2007–08, as these surveys included the same question about leisure time physical activity. All men in the municipality aged 20–54 and all women aged 20–49, totally 21 439 persons, were invited to the Tromsø Study in 1979–80, and the participation rate was 77.5%. Of the 16 620 participants, 5432 persons also participated in the Tromsø 3 and Tromsø 6 surveys with valid information on physical activity.

Paper II study population

In paper II, we included participants from the second Tromsø Study in 1979–80 who also attended BMD measurements in the fifth Tromsø Study in 2001–02. The baseline source population comprised total birth cohorts of men aged 20–54 years (born between 1925 and 1959) and women aged 20–49 years (born between 1930 and 1959) who were living in the municipality of Tromsø, totally 21 439 persons. Of those invited, 16,546 persons (77%) attended and answered the question on leisure time physical activity in Tromsø 2. Of the baseline cohort in Tromsø 2, 4443 persons were invited to participate in the DXA measurements in follow-up survey in Tromsø 5 in 2001–02. Altogether 3217 subjects (72%, 1766 women and 1451 men) attended the DXA measurements at follow-up.

Paper III study population

In paper III, the subjects were participants in the fourth Tromsø Study in 1994–95, to which all inhabitants in Tromsø, aged 25 years or older (born before 1970), were invited (n=37 558). A total of 27 158 persons (12 865 men and 14 293 women) aged 25-97 years attended, which corresponds to a participation rate of 75% in women and 70% in men. In our study, subjects aged 55 years and older (n=7582) were included. We excluded subjects with pathological fractures (n=12) and subjects with missing data on smoking (n=20), height (n=27), and body mass index (n=1), leaving 7522 subjects (3450 men and 4072 women) in the study cohort.

4.2 Assessment of physical activity

The participants in the Tromsø Study responded to a self-administered questionnaire concerning several life style and health related topics, including physical activity in leisure time and at work. Table 4 shows the questions about physical activity and exercise that are used in the thesis.

Table 4: Questions regarding physical activity in the Tromsø Study

Tromsø Study	Question	Answer options
Tromsø 1, 1974 Tromsø 2, 1979-80 Tromsø 3, 1986-87 Tromsø 5, 2001-02 <70 years Tromsø 6, 2007-08	State your bodily movement and physical exertion in leisure time. If your activity varies much, for example between summer and winter, then give an average. The question refers only to the last twelve months.	☐ Reading, watching TV or other sedentary activity ☐ Walking, cycling or other forms of exercise at least 4 hours a week (including walking or cycling to place of work, Sunday walking, etc.) ☐ Participation in recreational sports, heavy gardening, etc. Note: Duration of activity at least 4 hours a week ☐ Participation in hard training or sports competitions regularly several times a week
Tromsø 4, 1994-95 Tromsø 5, 2001-02	How has your leisure time physical activity been the last year? Think of a weekly average for the year. The way to work is counted as leisure time.	Light activity (not sweating or out of breath): ☐ None ☐ <1 hour ☐ 1-2 hours ☐ 3 or more hours pr. week Hard activity (sweating/out of breath): ☐ None ☐ <1 hour ☐ 1-2 hours ☐ 3 or more hours pr. week

4.3 Measurement of covariates

Adjustments for possible confounders were primarily done by baseline covariates. In paper I, possible confounders at follow-up in Tromsø 5 was also included. The Tromsø Study included self-administered questionnaire including numerous questions about lifestyle, and a physical examination, blood and urine samples[103]. The covariates are described in the papers.

4.4 Measurement of BMD

In Tromsø 5, BMD was measured at the distal and ultradistal forearm in 5771 subjects, in the non-dominant arm when eligible. Two different single X-ray absorptiometric (SXA) devices (DTX-100, Osteometer MediTech, Inc., Hawthorne, CA, USA) were used to measure BMD. In addition, BMD was measured at the hip in 4938 subjects. Dual-energy X-ray absorptiometry (DXA) (GE Lunar Prodigy, LUNAR Corporation, Madison, WI, USA) was used to measure BMD of the total hip, femoral neck, and trochanter area in the left hip when eligible. Technically incorrect scans, scans with metal in the region of interest and scans of hips with severe deformities were excluded. Specially trained technicians performed all scans according to the protocol provided by the manufacturer and reviewed and reanalyzed the scans if necessary. All densitometers underwent daily phantom measurements to secure stability[59].

4.5 Fracture registration

The radiographic archives of the University Hospital of North Norway in Tromsø comprise all non-vertebral fractures occurring in the municipality and thus in the study population, as there is no other radiography service in the city or within 250 kilometers. The only exception would be fractures occurring while travelling with no control radiograph after returning home or fractures never radiographically examined. Registered fractures are linked to the subjects in the Tromsø Study by use of the national personal identification number and time of investigation.

All radiographic examinations of participants in the fourth survey of the Tromsø Study were inspected to verify the fracture code. In subjects with fractures, the exact anatomical location of the fracture was identified and the trauma mechanism was categorized into high-energetic (fall from a height or traffic accident), low energetic (fall from same level, non-traffic accident), or pathologic (tumor or metastasis), and consecutive fracture events were distinguished from one another. The fracture registration at the University Hospital of North Norway (UNN) has been validated by Joakimsen et al.[105], as discussed in chapter 6.3.3.

4.6 Statistical analyses

All analyses were performed using SPSS (Statistical Package for Social Sciences, Chicago, IL, USA), version 16 and 18. Two-sided *P* values <0.05 were considered statistically significant. Most analyses were performed using sex stratification, although a few associations were analyzed in women and men combined to gain sufficient statistical power to be able to demonstrate a real association. Multiple analysis models included relevant and available confounders. Testing for interactions was

not done extensively, but confined to a few interaction terms, primarily the cross product of physical activity and sex or age, to examine possible effect modifications by sex or age. Subjects with missing values for exposure, outcome, or confounders were excluded from the analyses.

Descriptive characteristics of the study population were presented as mean (SD) or frequency (%), and differences between physical activity groups were tested (paper II and III). In all three papers, leisure time physical activity was the exposure, and in paper II also changes in physical activity from baseline to follow-up in a set of sub-analyses. The participants were divided into groups based on the answer options from the questionnaires. Outcomes were BMD, fracture risk, and osteoporosis. In the tracking study, physical activity level at follow-up was the outcome. BMD was assessed at the hip (total hip, femoral neck, trochanter) and forearm (distal and ultradistal). Fractures were divided into the first non-vertebral fracture, weight-bearing fractures, non-weight-bearing fractures, and hip and forearm fractures.

Follow-up time in paper III was assigned from the date of the screening to the date of the first fracture, migration from Tromsø, death, or end of follow-up (December 31, 2009), whichever came first. The date of the first fracture was used for the analyses of non-vertebral fractures and weight-bearing/non-weight-bearing fracture (disregarding subsequent fractures). In the analyses of relationships with hip and forearm fractures, the date of the first hip fracture, respectively forearm fracture, was used.

The associations between physical activity and BMD, osteoporosis, and fracture risk were analyzed using linear and Cox proportional hazards regression models (paper II and III). In paper I, we analyzed tracking of physical activity using three different measures. We first calculated the proportion of subjects who maintained their physical activity level from examination I to examination II and III, compared with the expected proportions. In order to compare the observed proportions of agreement with the proportions expected by chance, we used Cohen's weighted kappa. Because weighted kappa analysis is not available in SPSS, we used a syntax available on http://support.spss.com[237], using data generated from cross-tabulation of physical activity levels. Furthermore, the degree of tracking of physical activity was assessed by Spearman's correlation coefficients for physical activity between pairwise examinations. Finally, we used generalized estimating equations (GEE) models to measure tracking in terms of predictability of later values from earlier measurements, using physical activity in examination I as independent variable and physical activity in examination II and III as dependent variable. Tracking was estimated by the odds ratio (OR) of being at a specific physical activity level at later examinations, given belonging to the same level at examination I, relative to any other baseline physical activity level. Furthermore, we estimated the OR of being non-sedentary at later examinations according to physical activity level at examination I, with the dependent variable dichotomized into sedentary/non-sedentary.

5 Results – summary of papers

Paper I

The aim of this study was to examine tracking of leisure time physical activity in adults in Northern Norway over three decades. We followed 5432 women and men who attended the Tromsø Study in 1979-80 and repeated surveys after 7 and 28 years.

We found that a higher than expected proportion of subjects maintained their physical activity level from examination I to II (58%) and III (53%). Kappa statistics showed moderate agreement of 0.41 and 0.29, respectively. Furthermore, we found that being physically active in young adulthood increased the odds of being physically active later in life (moderately active OR 3.4, 95% Confidence Interval (CI): 3.0-3.9), active OR 5.4 (95% CI: 4.6-6.4), and highly active OR 13.0 (95% CI: 7.4-22.8) compared with being sedentary. Those who were sedentary as adults had higher odds of being sedentary later in life than those who were active (OR 3.9, 95% CI: 3.5-4.4).

In conclusion, this study demonstrated tracking of leisure time physical activity during 28 years in a cohort of adults, substantiated by physical activity levels in early adulthood being a strong predictor of an active lifestyle later in life and by moderate agreement between repeated measurements.

Paper II

In this population-based study, the aim was to examine the association between leisure time physical activity in adulthood and areal BMD 22 years later in 3217 women and men aged 20-54 years at baseline.

We observed a positive linear trend in BMD across physical activity levels in both women and men, after adjustments for baseline age, height, weight, and smoking status ($P < 0.05$). The relationship between BMD and leisure time physical activity was consistent over different sites of the hip (total hip, femoral neck and trochanter area) and forearm (distal and ultradistal area). In a subsample of 2436 men and women under 70 years, those who were sedentary at both baseline and follow-up had lower BMD than those who were physically active at either baseline and follow-up, or both ($P \leq 0.01$).

This study suggests that leisure time physical activity in adulthood is associated with higher BMD and reduced risk of osteoporosis later in life.

Paper III

The aim of this longitudinal cohort study was to examine the association between leisure time physical activity and the risk of non-vertebral fractures in 7522 women and men aged 55 years and older during a follow-up period of median 11 years.

A total of 1693 non-vertebral fractures were identified. Adjusted risk of any non-vertebral fracture decreased with increasing physical activity level in men (P_{trend} =0.005) and non-significantly in women (P_{trend} =0.2). The reduced fracture risk was mainly due to a reduced risk in the weight-bearing skeleton, whereas risk of fracture in the non-weight-bearing skeleton was not related to physical activity levels. At weight-bearing sites, an inverse relationship between physical activity and fracture risk was present in both sexes (P_{trend} ≤0.02). Compared with the sedentary subjects, the most active men and women had a 65% (HR=0.35, 95% CI: 0.16-0.75) and 55% (HR=0.45, 95% CI: 0.21-0.97) reduced fracture risk, whereas moderately active men and women had a 35% and 20% reduced fracture risk (HR=0.65, 95% CI: 0.46-0.92 in men and HR=0.80, 95% CI: 0.65-1.00 in women).

We concluded that in middle-aged and aged women and men, physical activity was protective against fractures at weight-bearing sites, but not at non-weight-bearing sites, indicating that effects of physical activity on fracture risk may be site-specific. Habitual physical activity seems to be an important non-pharmacological approach to prevent hip fracture, which is the most detrimental fracture.

6 Discussion of methodology

6.1 Internal and external validity

The validity of a study can be *internal,* i.e. refer to the inference drawn from the sample to the source population, or *external*, i.e. refer to the generalizability beyond the source population, to one or more target populations[10, 28].

Internal validity may be defined as "*a measure of how confident we can be that a difference in outcome between groups can be attributed to the effects of the exposure*"[57 p.80]. An observed association between the exposure and the outcome may be real (causal or non-causal) or have three other possible explanations, which are threats to the internal validity[25, 57]:

1. Chance
2. Bias (systematic errors)
3. Confounders

Bias can occur at every step of the research process and may be classified into various categories, though selection bias, measurement (or information) bias, and confounding are the most common categories.

6.2 Selection bias

Rothman[221 p.96] defines selection bias as "*a systematic error that results from procedures used to select subjects and from factors that influence study participation*". In causal association studies, selection bias may threaten the internal validity when the association between exposure (physical activity) and outcome (BMD and fractures) is different for the participants and non-participants[80, 221]. Selection bias may occur in the sampling process (due to selection procedures) or during follow-up (due to loss of participants)[221]. If the characteristics of the study participants differ systematically from those who were not selected, the external validity may be affected, without large impact on the internal validity.

In general, selection bias is not regarded a large problem in prospective cohort studies, because at the time of selection, the outcome is not known[93]. In our studies, any difference in non-response or withdrawal between physical activity groups is not likely related to fractures that occur many years later. Moreover, in a cohort study, a participation rate >80% is generally considered to be less likely to produce considerable selection bias[28, 93]. As shown in Table 3, the participation rates in the Tromsø Study surveys were close to or higher than 80%, and all residents of the municipality of Tromsø or a selected cohort among the inhabitants were invited to each survey. The participation rate for each of the papers is more

complex, as the inclusion of subjects required that participants were invited and attended repeated surveys, but in general, the participation rate relative to those who were eligible was high.

In conclusion, selection bias cannot be ruled out, but it seems reasonable to assume that it did not have a large impact on the results.

Table 3: Participation in the Tromsø Study surveys

Survey	Invited	Age (years)	Attended (n)	Participation rate* (% of invited)	
				Men	Women
Tromsø 2 1979-80	All women 20-49 years, all men 20-54 years	20-54	16 620	74	82
Tromsø 3 1986-87	All women 20-56 years, all men 20-61 years, and some younger and older subjects	12-67	21 826	72	79
Tromsø 4 1994-95	All inhabitants above the age of 25 years	25-97	27 158	70	75
Tromsø 5 2001-02	All inhabitants that attended the Tromsø 4 visit 2 survey and all residents aged 30, 40, 45, 60 or 75 years	30-89	8 130	76	81
Tromsø 6 2007-08	All participants in Tromsø 4 visit 2, a 10% random sample among inhabitants aged 30-39 years, a 40 % random sample among inhabitants aged 43-59 years, all inhabitants aged 40-42 years and 60-87 years	30-87	12 984	63	68

*Percentages are adjusted for those who had died, migrated or who were temporarily absent (travel etc.) on the time of the survey.

6.3 Measurement bias

Measurement errors may lead to bias. When the measurement error occurs with discrete variables, it is commonly referred to as misclassification[10]. Misclassification is an important issue, particularly when assessing behavior, such as physical activity. Misclassification can be non-differential or differential (bias). For a misclassification to be non-differential, the misclassification of physical activity must be unrelated to the outcome (BMD, fracture) and conversely[207]. Non-differential errors are less serious and will mostly weaken the real association, although with more than two groups, the directions may be more difficult to interpret[57, 80]. Differential misclassification is more serious and may distort the results in any direction[57].

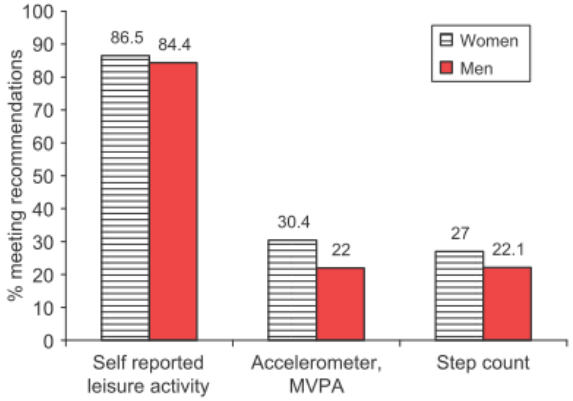
Some measurement biases are most common in case-control studies, such as recall bias[28], but in the three papers, there is one other bias that may particularly threaten the validity; reporting bias[10] may arise if the participants report incorrect information, consciously or unconsciously, and with physical activity, overestimation must be expected.

6.3.1 Validity of physical activity assessment methods

Physical activity is a complex behavior to assess, and assessment of physical activity can be done in several ways. Objective measures include measurement of energy expenditure (double labeled water, calorimeter or similar techniques) and movement monitors like accelerometer and pedometer[161]. Subjective assessments of physical activity include self-reporting methods by questionnaire, interview or diary[143, 161]. To measure targeted bone loading or force-generation activity, motion sensors and ground reaction forces together with questionnaire may be the most ideal method today[143]. Most epidemiological studies assessing physical activity, including the Tromsø Study, have to rely on questionnaires and do rarely have capacity to assess bone loading specifically. Self-administered questionnaires are very common because of low costs, feasibility, ability to reach large samples, and low burden for the participants. However, questionnaires have some disadvantages, which in the case of physical activity may relate to recall problems, misinterpretation, and the incapacity to assess different components of physical activity, possibly undermining reliability and validity[270].

In Tromsø 2, 3, and 6 physical activity was assessed by a single questionnaire (table 4). This question was originally initiated by Saltin and Grimby[224] 40 years ago and further developed for self-reporting by Wilhelmsen et al.[158]. The question has been widely used in population studies[7, 15, 152, 219].

To obtain *criterion-based validity*, validation of assessment instruments should primarily be performed based on correlation with direct, objective instruments that are considered as the gold standard[161]. However, such instruments are often too expensive and not feasible. During this thesis, a study of the physical activity question in Tromsø 6 (which was also used in Tromsø 2 and 3) validated against objectively measured physical activity was published[58]. In women and men aged 40-44 years, self-reported physical activity was positively associated with physical activity measured by accelerometer and steps/day in a dose-response relationship. There was also a positive association with maximal oxygen uptake (VO_{2max}) and an inverse association with resting heart rate. The study also utilized the same instruments to measure the proportion of subjects that met the national recommendations for physical activity. As shown i Figure 3, the proportion according to self-reported physical activity (the Tromsø Study question) was much higher than the proportion according to accelerometer and step count, indicating that self-reported physical activity may overestimate the real physical activity level. However, overestimation of physical activity level will probably underestimate the real effects of physical activity on the outcome. The study concluded that adult men and women estimate their physical activity level in accordance with objective measures of their physical activity level, and that this question has satisfactory validity to be used in epidemiological studies of physical activity and disease.



Percentage of adults meeting physical activity guidelines: self-reported leisure time activity, level 2–4; accelerometer, accumulation 30 min/day or more of moderate to vigorous physical activity (MVPA), in either one continuous bout, or several shorter bouts lasting i.e. 10 minutes; step count, minimum 10 000 steps per day; the Tromsø activity study (n=270).

Figure 3. Proportion of adults meeting physical activity guidelines. Reprinted with permissions from Scand J Public Health and the authors. *Emaus A et al. Does a variation in self-reported physical activity reflect variation in objectively measured physical activity, resting heart rate, and physical fitness? Results from the Tromsø study. Scand J Public Health 2010;38(5 Suppl):105-118*[58].

According to Anderssen et al.[7], there is evidence for acceptable construct validity for using this question in health surveys. In a study including 2860 women and men[115], physical activity in leisure time according to the question in the Tromsø Study was positively associated with metabolic equivalents (MET). Aadahl et al.[283] also found a linear trend for MET across levels of physical activity in leisure time in adult men and women. However, the validity may relate to studies of cardiovascular disease more than bone disease. Because the Tromsø Study and other large cohort studies originally focused primarily on cardiovascular disease, they mainly focused on physical activity that was beneficial to the heart. For bone disease, other aspects of physical activity may be beneficial than for aerobic fitness. Several studies have demonstrated that type of physical activity and partly intensity is more important to bone loading than frequency and duration. However, many activities that are beneficial to aerobic capacity are also beneficial to bone strength, by exerting external forces or muscle force on the bone.

Reliability of this question measured by test-retest administration after 4-6 weeks showed substantial reliability, with a Kappa value of 0.69[21] and 86% agreement[233].

Tromsø 4 used a different question regarding physical activity (Table 4). The question in Tromsø 2, 3, and 6 was not comparable with the Tromsø 4 questions, so we chose to exclude the Tromsø 4 population in the tracking paper (paper I). The two original physical activity questions in Tromsø 4 have been used in several large population studies[200, 241, 245], but we have found only one validation study of a small group

of men aged 20-39 years[153]. By comparing the characteristics of the physical activity groups, we found inverse dose-response relationships between physical activity and characteristics that are shown to be associated, for example BMI, smoking, and cardiovascular diseases.

6.3.2 Validity of BMD measurements

In paper II, BMD of the total hip, femoral neck, and trochanter area was measured by DXA (GE Lunar Prodigy, LUNAR Corporation, Madison, WI, USA). Two different SXA devices (DTX-100, Osteometer MediTech, Inc., Hawthorne, CA, USA) were used to measure areal BMD of the distal and ultradistal forearm. As presented in the introduction, DXA measured areal BMD is currently considered the gold standard for diagnosis of osteoporosis[42]. Furthermore, DXA and SXA densitometers are very practicable in use, with low costs, low radiation, and they are quick and easy to operate[32].

Generally, DXA and SXA measurements have excellent precision[32]. The Lunar Prodigy DXA densitometer was validated in a recent study[204] showing good agreement between the various Lunar Prodigy densitometers. Moreover, phantom measurements confirmed the in vivo measurements. The SXA method has also been shown sufficiently precise to establish BMD[220]. However, we believe that the precision errors that may occur during DXA and SXA measurements are probably random.

Although BMD is a strong predictor of fracture risk, there are some issues to consider. DXA and SXA measurements produce two-dimensional BMD and cannot assess three-dimensional size, structure and geometry, or microarchitecture of bone, nor separate between cortical and trabecular bone[32, 40]. However, because other indicators than areal BMD can influence bone strength, DXA measurements may actually underestimate the effects of physical activity on bone strength. Although there is a strong gradient between BMD and fracture risk, fractures often occur in individuals with BMD values in the normal range, and even low BMD values does not necessarily lead to fracture[118].

6.3.3 Validity of fracture registration

Misclassification in fracture registration may occur if patients are readmitted or transferred, or due to erroneous coding or punching[106]. The fracture registration at the University Hospital of Northern Norway (UNN) has been validated by Joakimsen et al.[105]. In a random sample of 1000 subjects from the Tromsø Study, one out of 68 fractures was not initially identified. This method, i.e. the use of a radiology database that was linked to the Tromsø Study database, was validated again by Joakimsen et al. in 2001[106], who concluded that the sensitivity of this method is very good and that the radiographic archive at UNN is accurate, as almost all fractures are coded correctly.

6.4 Confounding

"Confounding" originates from Latin, meaning "mix up"[25]. Confounding may be defined as "*distortion of an exposure-outcome association brought about by the association of another factor with both outcome and exposure*"[57 p.158], and may distort the real association in any direction[57]. The common strategies to control confounders are randomization, matching of subjects, restriction of selection criteria, stratification by certain characteristics, and statistical adjustments for potential confounders by use of multivariable models[25, 57]. However, in observational studies, it is impossible to control all other factors so that the groups only differ regarding the exposure, mostly due to ethical or logistic reasons[57].

Because this work includes all observational studies in which data were already collected, matching and randomization were not options. We therefore had to attempt to control confounders in the analyses. Our strategy was a combination of stratification, which was done by sex, and adjustments for confounders. Stratification may not be an option for every relevant confounder because it creates small subgroups, resulting in insufficient statistical power to do the statistical analyses[25]. We chose to stratify by sex in most analyses because sex is a common confounder, but also because we wanted to assess separate associations in women and men. Although the Tromsø Study has information on a large number of characteristics, the potential confounders were of course limited by the data material already collected. Potential confounders were chosen by comparing the characteristics of the population, and by selecting the most important factors that could be associated with both the exposure and the outcome. Still, there were probably unmeasured confounders in our studies, and there could also be residual confounding. Therefore, we cannot completely rule out confounding as an alternative explanation of the observed associations between physical activity and BMD and risk of fracture.

6.5 Generalizability (external validity)

External validity depends on internal validity, so if the results are not valid for the eligible subjects, judgment of the validity for other populations is irrelevant[57]. We have previously addressed internal validity and concluded that although errors may have occurred, there are probably no major distortions of the associations.

To obtain external validity, epidemiologists want to be able to generalize from the source population to a larger target population. Generalization may be viewed as whether the *sample (study population)* is representative for other populations, or whether the observed *associations* can be applied to other populations[10, 57]. In order to assess causality, as opposed to descriptive research, some epidemiologists argue that the subjects do not need to be a representative sample of larger populations, and this is often not feasible[10, 57]. The important issue is whether the *associations* between outcome and exposure can be

applied to a general population. This means generalizing from specific observations in the source population to a more universal hypothesis applicable to a nonspecific target population[10].

Even though the Tromsø population may not be entirely representative for Norway, the Nordic countries, Europe, or other geographic areas with regard to all aspects, for instance exposure to sun, snow and ice conditions, topography etc., the physiological associations between physical activity and BMD or fracture in adults are likely to apply to other populations than the Tromsø population. This is supported by the fact that results from physiological and genetic studies tend to have high external validity[57].

6.6 Causality

Ever since David Hume in the 18th Century characterized a causal relationship, researchers have developed criteria for determining whether a relationship is causal. Examples are "Mills canons" in the 19th Century, Hills criteria for a causal association[221], and Alfred Evan's postulates[210]. More recently, Bhopal[25] published a modification of these criteria for epidemiology:

1. Strength of association
2. Consistency of evidence
3. Specificity of relationship
4. Temporality
5. Dose-response
6. Biological plausibility
7. Experimental confirmation

Some epidemiologists have criticized the use of such criteria in establishing a causal relationship, claiming that they are vague or not applicable to all associations[25, 80, 221]. Furthermore, according to induction and refutationism, causality never can be proved, despite all these criteria. Nevertheless, examining causal relationships is crucial to medicine and public health[57]. Many epidemiologists emphasize that such criteria should create a framework for judgment of causality, based on evidence from all disciplines, and that common sense should be used in the evaluation; moreover, the conclusion about causality should not be finite[25]. Bhopal[25] argues that the criteria could be particularly useful in revealing lack of causality and for suggestions about further research.

Osteoporosis, like many other chronic diseases, has a complex etiology, and physical inactivity is one of many factors that may contribute to the development of osteoporosis. Although we found a beneficial association between physical activity and BMD, respectively fracture risk, in general most observed associations are actually not causal[25]. As shown in the previous chapters, bias and confounding must be examined and should be ruled out as explanations for the observed associations. We have concluded that

selection bias may have occurred, but due to the population based design and the high attendance rate, there are reasons to believe that selection bias may not have had a large impact on the result. Measurement of BMD and fracture registration are thoroughly validated and not likely encumbered with differential errors of importance. However, misclassification of physical activity could be considerable, but this misclassification is probably non-differential. A recent validation study[58] indicates that this single physical activity question seems to have satisfactory validity to be used in epidemiological studies of physical activity and disease, although self-reported physical activity may overestimate the real physical activity level and thus weaken the real associations. Although we adjusted for the assumed relevant confounders that were available, we cannot completely rule out unmeasured confounders as an explanation. Still, we conclude that the associations we observed were only modestly affected by bias and confounding, and by using P values ⩽0.05 and 95% confidence intervals in the statistical analyses, the possibility that chance was an explanation for the results was weakened.

Inferring about causality from a single study is generally not recommended. Therefore, in this thesis we will not aim at drawing final conclusions about causality, but rather use some of the criteria as a basis for a discussion of some issues related to the results. Besides temporality, which is necessary for a causal relationship (the cause must precede the effect)[25, 221], the plausibility of the results, as well as the strength and consistence with previous research, are central principles when evaluating epidemiological research.

7 Discussion of results - interpretation and context

7.1 Strength of the association and dose-response relationship

A dose-response relationship between exposure and outcome is an indicator of the strength of the observed associations[28]. Additionally, the dose-response relationship may also have implications for public health advice about physical activity[80, 161]. Because a large proportion of individuals does not meet the recommendations for physical activity, health authorities commonly advice the minimum of activity needed for health benefits[161].

Physical activity can be explained by intensity, frequency, duration, type, or total volume (intensity, frequency, and duration), and may have different effects depending on these aspects, as well as the goal of the activity (endurance or resistance skills, lower body weight etc.)[161]. The physical activity question in paper II partly covers duration (more or less than 4 hours per week) and is a crude measure of intensity, but does not cover type or frequency of the activity. Therefore, we have used the answer as an estimate of the volume of activity. The dose-response relationship between volume of physical activity and BMD (paper II) and fracture (paper III) strengthens the observed associations in the thesis.

Generally, total volume is regarded sufficient to show a dose-response relationship, although too inaccurate to find the exact level of physical activity to prevent disease[161]. Still, in paper II there is a cut-off point at 4 hours a week between the sedentary and moderate categories, which means that physical activity in paper II, defined as activity more than four hours per week with moderate or high intensity, is in accordance with the Nordic Health Authorities' recommendations, which is 30 minutes physical activity with moderate intensity most days of the week[8]. The physical activity questions in paper III are less suited to measure physical activity in relation to the national physical activity recommendations.

Aiming at describing a dose-response relationship has consequences for the choice of statistical methods. In the statistical analysis, physical activity can be treated as a categorical or continuous variable. In the present work, physical activity was modeled as both as a categorical and as a continuous variable; one reason for this choice is obviously that we wanted to describe a kind of dose-response relationship, as well as detect differences between high and low physical activity levels.

The strength of the associations may also be evaluated based on the effect size[25]. In this work, the associations were not very strong, as HRs and BMD differences were mostly small or moderate. This is however expected in studies of physical activity, as the physical activity level in a general population is rather low. Furthermore, physical activity is one of many risk factors that may explain or predict BMD and fracture.

7.2 Biological plausibility

There are some well-grounded theories behind the biological mechanisms explaining associations between physical activity and fracture, as described in the introduction (mechanical loading and mechanotransduction, improved muscle strength, balance, and neuromuscular control). Low BMD is a risk factor for fracture, and physical activity may reduce the incidence of fractures by the mechanisms of mechanical loading. Our results cannot directly identify the biological mechanisms responsible for lower fracture risk associated with physical activity, but the observed association between both physical activity and fracture at the hip, and also between physical activity and BMD, could imply that BMD is partly involved in these mechanisms.

Although the subjects in paper II and III were from different Tromsø Study surveys, they have probably been engaged in the same type of activities (some of the subjects may have been included in both studies). Although we do not have information about the type of activity, it seems reasonable to assume that habitual physical activity primarily involves the lower skeleton, as walking is the decidedly most common activity among Norwegians[6]. However, we found that both hip and forearm BMD were positively associated with physical activity in a linear trend, and the same trend was found between physical activity and fractures at the hip, but not the forearm. The reason for this is not clear, but higher BMD in the forearm does not seem to protect against forearm fracture. This could indicate that other skeletal mechanisms are involved, or that falls are a stronger determinant for fracture than BMD, as suggested by Järvinen et al.[104].

Not all fractures occur in osteoporotic patients[238], and physical activity may also prevent fracture through improved muscle strength and balance. Several observational studies have shown that physical activity (particularly resistance and balance training) reduces the incidence of falls[37, 125, 133], also in people with low BMD[49]. Most, but not all RCTs support these results[133]. Unfortunately, we did not have data on falls in relation to fractures.

Physical activity may also reduce fracture risk through other mechanisms than BMD, by positively affecting structural properties of the bone[47, 257]. Some animal studies have shown that exercise induces positive changes in bone strength and structure, but not BMD[267], demonstrating the limitations of DXA BMD measurements in giving information about cortical and trabecular structure, size, shape, and bone mass distribution[196]. Recently, advances in imaging techniques (pQCT, MRI) have made it possible to assess bone strength more properly. pQCT can be used to assess macroarchitecture, and trabecular and cortical bone density as volumetric BMD (g/cm^3), and MRI can assess trabecular microarchitecture, however at peripheral sites[30]. More recently developed techniques include high-resolution micro-computed tomography and finite element analysis[30]. Quantitative ultrasound can also be used to measure bone mineral and architecture[88]. These instruments can measure other aspects of bone strength,

including bone strength index (BSI), stress-strain index (SSI), cross-sectional moment of inertia (CSMI) and section moduli (Z), and maximal moment of inertia (Imax)[196]. We did however not have access to such instruments in this work. A review of RCTs measuring exercise effects on bone strength mostly showed no significant effects in adolescence, middle-aged, and older individuals, but a small effect in young boys[196]. However, the studies are few and short-term, and no RCTs including men were found. The review revealed that the instruments for measuring bone strength still are subject to technical challenges. A review of all types of studies in older women[87] showed a little more promising results with positive but modest exercise effects on bone geometry at loaded sites. Similarly, Daly and Bass[47] reported that lifetime and mid-adulthood physical activity was associated with 6-15% higher mid-femur total and cortical areas measured by quantitative computed tomography (QCT), while there was no observed association between areal BMD and lifetime physical activity. As suggested by Daly and Bass, because of the two-dimensional nature of areal BMD measures, DXA may actually underestimate the effect of physical activity on bone strength.

7.3 Consistency with previous research

In this section, the results from each paper will be commented and placed in the context of other results in this thesis, as well as in a larger context, and the results will be discussed in general. The results are compared with previous results in more detail in the enclosed papers I-III.

Causality between physical activity and BMD needs to be demonstrated in experiments (RCTs) or laboratory studies, to control the factors that may bias or confound the results, but such intervention studies are not well suited for exploration of long-term effects of physical activity, because of their short duration and limited number of participants. Therefore, investigations of long-term effects of physical activity on BMD are usually based on epidemiological studies, either prospective or case-control (retrospective) studies. Epidemiological observation studies are important in order to confirm findings from RCTs in studies that assemble real-life in large populations[25], and repeated population studies, such as the Tromsø Study, are suited for long-term analyses.

7.3.1 Tracking of physical activity

Tracking of physical activity habits during adulthood has not been object of many studies. Moreover, the existing studies have been performed with different physical activity categories and cut-offs, and with varying time span and methods; therefore, comparison with previous research is problematic. Yet, in paper I, we made an effort to compare our results with previous studies. In terms of correlation between repeated measurements, which is the most commonly used measure for tracking, our results are in agreement with previous studies[48, 72, 144, 162, 163, 223, 242], showing moderate tracking. Several methods are available for analyses of tracking, and we furthermore examined prediction of physical activity levels

from earlier measurements of physical activity. By using GEE models, we added a new procedure to the literature of physical activity tracking. We found that physical activity in adulthood was a strong predictor of later physical activity levels, with high ORs. The only other study we found that was comparable with this method reported similar results[144].

Finally, we calculated the proportion who maintained their physical activity level after 28 years. Our results indicated that 58% and 53% of the participants remained at their baseline physical activity level after 7 and 28 years, respectively. These results are not easily comparable with similar studies (which, again, are few) because physical activity is categorized differently. Consequently, these results seem difficult to interpret; is 58% an adequate proportion for the study of associations between physical activity and BMD or fracture incidence? What is the signification of these results for health outcomes?

In terms of health benefits, high levels of tracking can be interpreted as both advantageous and unfortunate, since habitual physical activity is beneficial to health, while inactivity is undesirable. Our findings that more than 25% decreased their physical activity level over time indicate that effort should be directed at continuing an active lifestyle. In terms of relevance for epidemiological studies, the proportion of participants that did not change their physical activity level (between 50% and 60%) was statistically higher than expected, but the relevance must be based on subjective opinions. If we add those who decreased their physical activity level (26%-27%), which may have attenuated the associations, it seems reasonable that an observed association in paper II and III rest on the assumption that physical activity levels were relatively stable throughout the follow-up period. Furthermore, it is evident that physical activity level is strongly associated with later physical activity levels.

After the submission of this paper, a new study[188] using internet tracking of self-reported physical activity was published. The study is interesting because it follows community-living women in real-time weekly for 2.5 years, and the results show that physical activity habits are very stable across long periods, which support the assumption that physical activity habits in adults are rather stable. Another new study of tracking of physical activity in adults was published in 2011[208]. Tracking of physical activity over 10 years was studied in 3258 Dutch adult men and women, showing that 31.4% of the populations were active throughout the time period. Once again, the methods used differed slightly between our study and this Dutch study, so most numbers are not directly comparable. They reported that 45% changed their physical activity habits, which is comparable and similar to our numbers. The authors highlight an essential argument; with these individual changes in physical activity habits over time, the strong and consistent effects of physical activity that are found in many health studies are striking and could actually be much higher[208].

7.3.2 Long-term associations between physical activity and BMD

Retrospective studies, which are susceptible to recall bias, have reported inconsistent results, and only a few prospective studies have examined the long-term association between physical activity during adulthood and BMD at older ages. Augestad et al.[12] reported that physical activity was protective against low forearm BMD 11 years later in 2924 Norwegian postmenopausal women in Trøndelag (the HUNT study). Daly et al.[46] examined forearm BMD in 358 elderly women and men with repeated measurements 10 years apart. They found a lower bone loss in individuals who were physically active over 10 years than in those who were sedentary over the period. In our study (paper II), we were able to examine hip BMD as well. We observed that higher levels of physical activity were associated with higher BMD 22 years later, both in forearm, as did the Daly et al.[46] and Augestad et al.[12], and also at the hip. Our study thus extends the existing knowledge about long-term benefits of physical activity into middle age and old age. However, in contrast to Daly et al.[46], we did not have baseline measurements of BMD, which may impede the ability to show a causal relationship.

With only one measure of physical activity in our study, it is uncertain whether the higher BMD in active vs. sedentary participants is a result of continued physical activity in the active subjects or prolonged effects of physical activity 20 years earlier. Paper I examined the stability of physical activity over 28 years, showing that the proportion of participants who maintained their physical activity level was 50% to 60%. Adding those who decreased their physical activity level (26%-27%), which may have attenuated the associations, it seems reasonable to assume a fairly stable physical activity level over decades.

We did however have follow-up assessment of physical activity among a subsample of the participants in Tromsø 2 (those aged < 70 years at follow-up in 2001). The sub-analyses showed that 71% of the paper II population were active and 6% were sedentary at both examinations, thus an even higher proportion of participants than found in paper I maintained their physical activity level. Interestingly, those who were sedentary at both surveys had lower BMD than those who were moderately active or active at one or both surveys. These results indicate that any activity is better than being sedentary, and that not only past, but also recent activity may influence BMD. However, the subgroup excluded all subjects older than 70 years and the results may thus not relate to older people.

The positive trends in BMD across physical activity levels in paper II were consistent across all measured sites, implying an association between physical activity and fracture risk as well. This provided the basis for paper III, in which the aim was to study physical activity in relation to fracture risk. Unfortunately, we could not assess fracture risk in paper II, because we analyzed the Tromsø 2 population which was examined in 1979-80, whereas the fracture registry started in 1988. Thus, we chose the large Tromsø 4 population (1994-95) as study population for paper III.

7.3.3 Physical activity and fracture risk

There is no uniform definition of an osteoporotic fracture[107, 120]. Historically, fractures of the hip, spine, and distal forearm have been considered the main osteoporotic fractures[39] . Another approach has been to define low-energy fractures (i.e. falling from the same level) as osteoporotic, but patients with low BMD are probably more likely to suffer a fracture from a high-energy trauma as well, compared with non-osteoporotic patients[107]. Kanis[120] discusses yet another definition of osteoporotic fracture as "*sustained in an individual over the age of 50 years at a site that increases in frequency the lower the BMD, increases in incidence with age, and provides a risk indicator for future osteoporotic fracture*"[120 p.92]. Our definition of an osteoporotic fracture is largely in accordance with this definition, as we chose to exclude only clearly high trauma fracture sites. However, because most studies have focused on hip and forearm fractures, we also did sub-analyses of these two fracture sites, in order to be able to compare our results with the previous studies.

Our results of the associations between physical activity and risk of fracture in the hip and forearm were generally in accordance with previous studies, although studies of physical activity in relation to forearm fractures are few and inconsistent. The main objective of paper III was to examine fracture risk at weight-bearing versus non-weight-bearing sites, which was possible because of the large cohort with a large number of fractures. Paper III can be viewed as a continuation of a previous study of the Tromsø cohort by Joakimsen et al.[105], who examined physical activity in relation to fractures at weight-bearing and non-weight-bearing sites in the cohorts of Tromsø 2 and 3. Joakimsen et al.[105] found that high physical activity was associated with a significantly lower risk of fracture in the lower (weight-bearing) extremities, although non-significant in women. Our study analyzed data from the fourth Tromsø Study survey, which is partly a different cohort, still the results were similar to the previous study by Joakimsen et al.[105]. Similarly, none of these two studies found associations between physical activity and risk of fracture at non-weight-bearing sites.

On the other hand, two recent studies report that higher physical activity levels may actually increase the risk of fracture in elderly individuals[9, 195]. These results indicate that physical activity also may represent an increased risk of fracture, and although our study may have pointed to an important issue regarding the different benefits in the weight-bearing and non-weight-bearing skeleton, more research is needed to clarify the role of physical activity in fracture prevention.

8 Conclusions, implications and future research

8.1 Conclusions

Main conclusion 1: Physical activity habits in adulthood are a strong determinant of physical activity habits later in life.

- 53% of the subjects maintained their physical activity over 28 years. 27% decreased and 20% increased their level of physical activity.
- Sedentary adults have higher odds of being sedentary later in life than active adults.
- Being physically active in adulthood is a strong predictor of being active later in life.

Main conclusion 2: Being physically active in adulthood seems to reduce the risk of osteoporosis later in life, at ages when individuals are more prone to fragility fractures.

- There is a positive dose-response relationship between physical activity in adulthood and BMD measured later in life.
- Being physically active in early or late adulthood, or both, is beneficial to BMD compared with being sedentary throughout adulthood.

Main conclusion 3: Physical activity seems to protect against fractures in the weight-bearing skeleton in subsequent years in middle-aged and aged women and men.

- Being highly active in adulthood reduces the risk of fracture in the weight-bearing skeleton by 55-65% compared with being sedentary.
- In non-weight-bearing skeleton, risk of fracture is not related to physical activity. Thus, effects of physical activity on fracture risk seem to be site-specific.

8.2 Implications for public health

- Many individuals maintain their sedentary lifestyle or decrease their activity level from early or middle adulthood into older age, which implies that adults and elderly should be considered as target groups for public health interventions that promote physical activity.

- It is important that physical activity habits during childhood and adolescence are carried forward into adulthood, as being active in early or middle adulthood increases the odds of being active at older ages.

- Physical activity during adulthood should be encouraged as part of the prevention of osteoporosis and preservation of bone mass. Physical activity in the prevention of osteoporosis should be encouraged among older people as well, as being active in early or late adulthood, or both, is more beneficial to BMD than being sedentary throughout adulthood.

- Following the recommendations from the Norwegian health authorities about exertion of physical activity may be sufficient for significant BMD preservation later in life. Higher activity levels may further escalate the BMD benefits.

- In order to prevent hip fractures, which are the most serious fracture, weight-bearing physical activity should be recommended.

8.3 Future research

The association between physical activity and BMD has been studied extensively for 30 years, both in cross-sectional studies, longitudinal observation studies, and RCTs. Yet, there are some unsolved questions.

1. Because most studies are short-term, long-term changes in physical activity should be assessed in relation to long-term changes in BMD, as one remodeling cycle takes up to 5 months.

2. Assessment of physical activity is often based on subjective measurements, thus objective measurement of physical activity should be performed when possible, and assessment of physical activity should include the specific components of physical activity (frequency, intensity, type, and duration).

3. Assessing type of activity is crucial because of the mechanical loading theory. Many different types of activity seem to be beneficial, and future research should focus on which types of activity (weight-bearing, resistance, walking etc.) are most useful for osteoporosis prevention.

4. Because BMD measures only one aspect of bone strength, measurements of bone structure in relation to physical activity should be encouraged, along with development of methods and instruments to assess bone structure.

The association between physical activity and fractures has been much less examined, and there are many uncertain areas. Long-term RCTs are not likely to be performed on physical activity and fracture. There are too many restraining aspects, such as the long time period needed, expensiveness, the number of subjects needed, and the ethics of requesting people to be more or less sedentary for a long time. Most suggestions above also relate to physical activity and fracture risk, though there are some additional aspects of interest:

5. Most studies involve hip, but the effects of physical activity at other fracture sites should also be examined.

6. Falls are a very important aspect when studying fracture. Thus, physical activity and fracture studies should include data on fall incidence.

Regarding habits of physical activity, future studies may examine determinants or predictors of physical activity and secular trends in physical activity over decades. Moreover, more comprehensive and standardized questionnaires are needed for a better foundation for comparison between populations in epidemiological studies when objective assessment of physical activity is not possible.

References

1. Abrahamsen B, van Staa T, Ariely R, Olson M, and Cooper C. Excess mortality following hip fracture: a systematic epidemiological review. *Osteoporos Int* 2009.
2. Ahmed LA, Schirmer H, Bjørnerem A, Emaus N, Jørgensen L, Størmer J, and Joakimsen RM. The gender- and age-specific 10-year and lifetime absolute fracture risk in Tromsø, Norway. *Eur J Epidemiol* 2009;24(8):441-448.
3. Albright A, Franz M, Hornsby G, Kriska A, Marrero D, Ullrich I, and Verity LS. American College of Sports Medicine position stand. Exercise and type 2 diabetes. *Med Sci Sports Exerc* 2000;32(7):1345-1360.
4. Ammann P, and Rizzoli R. Bone strength and its determinants. *Osteoporos Int* 2003;14 Suppl 3:S13-18.
5. Anderssen N, Jacobs DR, Jr., Sidney S, Bild DE, Sternfeld B, Slattery ML, and Hannan P. Change and secular trends in physical activity patterns in young adults: a seven-year longitudinal follow-up in the Coronary Artery Risk Development in Young Adults Study (CARDIA). *Am J Epidemiol* 1996;143(4):351-362.
6. Anderssen S, and Helsedirektoratet. *Fysisk aktivitet blant voksne og eldre i Norge : resultater fra en kartlegging i 2008 og 2009*. Oslo: Helsedirektoratet; 2009.
7. Anderssen SA, Engeland A, Søgaard AJ, Nystad W, Graff-Iversen S, and Holme I. Changes in physical activity behavior and the development of body mass index during the last 30 years in Norway. *Scand J Med Sci Sports* 2008;18(3):309-317.
8. Anderssen SA, and Strømme SB. [Physical activity and health--recommendations]. *Tidsskr Nor Laegeforen* 2001;121(17):2037-2041.
9. Appleby PN, Allen NE, Roddam AW, and Key TJ. Physical activity and fracture risk: a prospective study of 1898 incident fractures among 34,696 British men and women. *J Bone Miner Metab* 2008;26(2):191-198.
10. Armitage P, and Colton T. *Encyclopedia of biostatistics*. Chichester: Wiley; 1998.
11. Armstrong ME, Spencer EA, Cairns BJ, Banks E, Pirie K, Green J, Wright FL, Reeves GK, and Beral V. Body mass index and physical activity in relation to the incidence of hip fracture in postmenopausal women. *J Bone Miner Res* 2010.
12. Augestad LB, Schei B, Forsmo S, Langhammer A, and Flanders WD. Healthy postmenopausal women-physical activity and forearm bone mineral density: The Nord-Trondelag Health Survey. *J Women Aging* 2006;18(1):21-40.
13. Baggett CD, Stevens J, McMurray RG, Evenson KR, Murray DM, Catellier DJ, and He K. Tracking of physical activity and inactivity in middle school girls. *Med Sci Sports Exerc* 2008;40(11):1916-1922.

14. Bahr R, and Helsedirektoratet. *Aktivitetshåndboken : fysisk aktivitet i forebygging og behandling*. [Oslo]: Helsedirektoratet; 2009.
15. Barengo NC, Nissinen A, Pekkarinen H, Halonen P, and Tuomilehto J. Twenty-five-year trends in lifestyle and socioeconomic characteristics in Eastern Finland. *Scand J Public Health* 2006;34(4):437-444.
16. Barnekow-Bergkvist M, Hedberg G, Pettersson U, and Lorentzon R. Relationships between physical activity and physical capacity in adolescent females and bone mass in adulthood. *Scand J Med Sci Sports* 2006;16(6):447-455.
17. Barry DW, and Kohrt WM. Exercise and the preservation of bone health. *J Cardiopulm Rehabil Prev* 2008;28(3):153-162.
18. Bass SL, Saxon L, Daly RM, Turner CH, Robling AG, Seeman E, and Stuckey S. The effect of mechanical loading on the size and shape of bone in pre-, peri-, and postpubertal girls: a study in tennis players. *J Bone Miner Res* 2002;17(12):2274-2280.
19. Bassey EJ, and Ramsdale SJ. Increase in femoral bone density in young women following high-impact exercise. *Osteoporos Int* 1994;4(2):72-75.
20. Bassey EJ, Rothwell MC, Littlewood JJ, and Pye DW. Pre- and postmenopausal women have different bone mineral density responses to the same high-impact exercise. *J Bone Miner Res* 1998;13(12):1805-1813.
21. Batty D. Reliability of a physical activity questionnaire in middle-aged men. *Public Health* 2000;114:474-476.
22. Beck BR, and Snow CM. Bone health across the lifespan--exercising our options. *Exerc Sport Sci Rev* 2003;31(3):117-122.
23. Bennell KL, Malcolm SA, Khan KM, Thomas SA, Reid SJ, Brukner PD, Ebeling PR, and Wark JD. Bone mass and bone turnover in power athletes, endurance athletes, and controls: a 12-month longitudinal study. *Bone* 1997;20(5):477-484.
24. Berntsen GK, Fønnebø V, Tollan A, Søgaard AJ, and Magnus JH. Forearm bone mineral density by age in 7,620 men and women: the Tromsø study, a population-based study. *Am J Epidemiol* 2001;153(5):465-473.
25. Bhopal RS. *Concepts of epidemiology: integrating the ideas, theories, principles and methods of epidemiology*. Oxford: Oxford University Press; 2008.
26. Bonaiuti D, Shea B, Iovine R, Negrini S, Robinson V, Kemper HC, Wells G, Tugwell P, and Cranney A. Exercise for preventing and treating osteoporosis in postmenopausal women. *Cochrane Database Syst Rev* 2002;(3):CD000333.
27. Bonewald LF, and Johnson ML. Osteocytes, mechanosensing and Wnt signaling. *Bone* 2008;42(4):606-615.
28. Boslaugh S. *Encyclopedia of epidemiology*. Los Angeles: Sage Publications; 2008.

29. Bouxsein ML. Mechanisms of osteoporosis therapy: a bone strength perspective. *Clin Cornerstone* 2003;Suppl 2:S13-21.
30. Bouxsein ML. Non-invasive measurements of bone strength: promise and peril. *J Musculoskelet Neuronal Interact* 2004;4(4):404-405.
31. Bouxsein ML. Determinants of skeletal fragility. *Best Pract Res Clin Rheumatol* 2005;19(6):897-911.
32. Bouxsein ML. Technology insight: noninvasive assessment of bone strength in osteoporosis. *Nat Clin Pract Rheumatol* 2008;4(6):310-318.
33. Bouxsein ML, and Karasik D. Bone geometry and skeletal fragility. *Curr Osteoporos Rep* 2006;4(2):49-56.
34. Brownbill RA, Lindsey C, Crncevic-Orlic Z, and Ilich JZ. Dual hip bone mineral density in postmenopausal women: geometry and effect of physical activity. *Calcif Tissue Int* 2003;73(3):217-224.
35. Burge R, Dawson-Hughes B, Solomon DH, Wong JB, King A, and Tosteson A. Incidence and economic burden of osteoporosis-related fractures in the United States, 2005-2025. *J Bone Miner Res* 2007;22(3):465-475.
36. Burger EH, Klein-Nulend J, van der Plas A, and Nijweide PJ. Function of osteocytes in bone--their role in mechanotransduction. *J Nutr* 1995;125(7 Suppl):2020S-2023S.
37. Carter ND, Kannus P, and Khan KM. Exercise in the prevention of falls in older people: a systematic literature review examining the rationale and the evidence. *Sports Med* 2001;31(6):427-438.
38. Chen J-H, Liu C, You L, and Simmons CA. Boning up on Wolff's Law: Mechanical regulation of the cells that make and maintain bone. *J Biomech* 2010;43(1):108-118.
39. Cole ZA, Dennison EM, and Cooper C. Osteoporosis epidemiology update. *Curr Rheumatol Rep* 2008;10(2):92-96.
40. Cole Za, Dennison EM, and Cooper C. The impact of methods for estimating bone health and the global burden of bone disease. *Salud Publica Mex* 2009;51 Suppl 1:S38-45.
41. Consensus development conference. Diagnosis, prophylaxis, and treatment of osteoporosis. *Am J Med* 1993;94(6):646-650.
42. Cummings SR, Bates D, and Black DM. Clinical use of bone densitometry: scientific review. *JAMA* 2002;288(15):1889-1897.
43. Cummings SR, and Melton LJ. Epidemiology and outcomes of osteoporotic fractures. *Lancet* 2002;359(9319):1761-1767.
44. Cummings SR, Nevitt MC, Browner WS, Stone K, Fox KM, Ensrud KE, Cauley J, Black D, and Vogt TM. Risk factors for hip fracture in white women. Study of Osteoporotic Fractures Research Group. *N Engl J Med* 1995;332(12):767-773.
45. Daley MJ, and Spinks WL. Exercise, mobility and aging. *Sports Med* 2000;29(1):1-12.

46. Daly RM, Ahlborg HG, Ringsberg K, Gardsell P, Sernbo I, and Karlsson MK. Association between changes in habitual physical activity and changes in bone density, muscle strength, and functional performance in elderly men and women. *J Am Geriatr Soc* 2008;56(12):2252-2260.
47. Daly RM, and Bass SL. Lifetime sport and leisure activity participation is associated with greater bone size, quality and strength in older men. *Osteoporos Int* 2006;17(8):1258-1267.
48. De Bourdeaudhuij I, Sallis J, and Vandelanotte C. Tracking and explanation of physical activity in young adults over a 7-year period. *Res Q Exerc Sport* 2002;73(4):376-385.
49. de Kam D, Smulders E, Weerdesteyn V, and Smits-Engelsman BC. Exercise interventions to reduce fall-related fractures and their risk factors in individuals with low bone density: a systematic review of randomized controlled trials. *Osteoporos Int* 2009;20(12):2111-2125.
50. Delvaux K, Lefevre J, Philippaerts R, Dequeker J, Thomis M, Vanreusel B, Claessens A, Eynde BV, Beunen G, and Lysens R. Bone mass and lifetime physical activity in Flemish males: a 27-year follow-up study. *Med Sci Sports Exerc* 2001;33(11):1868-1875.
51. Donnelly JE, Blair SN, Jakicic JM, Manore MM, Rankin JW, and Smith BK. American College of Sports Medicine Position Stand. Appropriate physical activity intervention strategies for weight loss and prevention of weight regain for adults. *Med Sci Sports Exerc* 2009;41(2):459-471.
52. Dornemann TM, McMurray RG, Renner JB, and Anderson JJ. Effects of high-intensity resistance exercise on bone mineral density and muscle strength of 40-50-year-old women. *J Sports Med Phys Fitness* 1997;37(4):246-251.
53. Duncan CS, Blimkie CJ, Cowell CT, Burke ST, Briody JN, and Howman-Giles R. Bone mineral density in adolescent female athletes: relationship to exercise type and muscle strength. *Med Sci Sports Exerc* 2002;34(2):286-294.
54. Duppe H, Gardsell P, Johnell O, and Ornstein E. Bone mineral density in female junior, senior and former football players. *Osteoporos Int* 1996;6(6):437-441.
55. Eastell R, Boyle IT, Compston J, Cooper C, Fogelman I, Francis RM, Hosking DJ, Purdie DW, Ralston S, Reeve J, Reid DM, Russell RG, and Stevenson JC. Management of male osteoporosis: report of the UK Consensus Group. *QJM* 1998;91(2):71-92.
56. EFFO and NOF. Who are candidates for prevention and treatment for osteoporosis? *Osteoporos Int* 1997;7(1):1-6.
57. Elwood JM. *Critical appraisal of epidemiological studies and clinical trials*. 3rd ed. Oxford ; New York: Oxford University Press; 2007.
58. Emaus A, Degerstrom J, Wilsgaard T, Hansen BH, Dieli-Conwright CM, Furberg AS, Pettersen SA, Andersen LB, Eggen AE, Bernstein L, and Thune I. Does a variation in self-reported physical activity reflect variation in objectively measured physical activity, resting heart rate, and physical fitness? Results from the Tromsø study. *Scand J Public Health* 2010;38(5 Suppl):105-118.

59. Emaus N, Berntsen GK, Joakimsen R, and Fønnebø V. Bone mineral density measures in longitudinal studies: the choice of phantom is crucial for quality assessment. The Tromsø study, a population-based study. *Osteoporos Int* 2005;16(12):1597-1603.
60. Emaus N, Berntsen GK, Joakimsen R, and Fønnebø V. Longitudinal changes in forearm bone mineral density in women and men aged 45-84 years: the Tromsø Study, a population-based study. *Am J Epidemiol* 2006;163(5):441-449.
61. Emaus N, Berntsen GK, Joakimsen RM, and Fønnebø V. Longitudinal changes in forearm bone mineral density in women and men aged 25-44 years: the Tromsø study: a population-based study. *Am J Epidemiol* 2005;162(7):633-643.
62. Emaus N, Olsen LR, Ahmed LA, Balteskard L, Jacobsen BK, Magnus T, and Ytterstad B. Hip fractures in a city in Northern Norway over 15 years: time trends, seasonal variation and mortality : The Harstad Injury Prevention Study. *Osteoporos Int* 2011.
63. Emaus N, Omsland TK, Ahmed LA, Grimnes G, Sneve M, and Berntsen GK. Bone mineral density at the hip in Norwegian women and men--prevalence of osteoporosis depends on chosen references: the Tromsø Study. *Eur J Epidemiol* 2009;24(6):321-328.
64. Etherington J, Harris PA, Nandra D, Hart DJ, Wolman RL, Doyle DV, and Spector TD. The effect of weight-bearing exercise on bone mineral density: a study of female ex-elite athletes and the general population. *J Bone Miner Res* 1996;11(9):1333-1338.
65. Falch JA, Kaastad TS, Bohler G, Espeland J, and Sundsvold OJ. Secular increase and geographical differences in hip fracture incidence in Norway. *Bone* 1993;14(4):643-645.
66. Farmer ME, Harris T, Madans JH, Wallace RB, Cornoni-Huntley J, and White LR. Anthropometric indicators and hip fracture. The NHANES I epidemiologic follow-up study. *J Am Geriatr Soc* 1989;37(1):9-16.
67. Fehling PC, Alekel L, Clasey J, Rector A, and Stillman RJ. A comparison of bone mineral densities among female athletes in impact loading and active loading sports. *Bone* 1995;17(3):205-210.
68. Feskanich D, Willett W, and Colditz G. Walking and leisure-time activity and risk of hip fracture in postmenopausal women. *JAMA* 2002;288(18):2300-2306.
69. Foley S, Quinn S, Dwyer T, Venn A, and Jones G. Measures of childhood fitness and body mass index are associated with bone mass in adulthood: a 20-year prospective study. *J Bone Miner Res* 2008;23(7):994-1001.
70. Forsen L, Søgaard AJ, Meyer HE, Edna T, and Kopjar B. Survival after hip fracture: short- and long-term excess mortality according to age and gender. *Osteoporos Int* 1999;10(1):73-78.
71. Forsmo S, Langhammer A, Forsen L, and Schei B. Forearm bone mineral density in an unselected population of 2,779 men and women--the HUNT Study, Norway. *Osteoporos Int* 2005;16(5):562-567.

72. Fortier MD, Katzmarzyk PT, Malina RM, and Bouchard C. Seven-year stability of physical activity and musculoskeletal fitness in the Canadian population. *Med Sci Sports Exerc* 2001;33(11):1905-1911.
73. French SA, Fulkerson JA, and Story M. Increasing weight-bearing physical activity and calcium intake for bone mass growth in children and adolescents: a review of intervention trials. *Prev Med* 2000;31(6):722-731.
74. Friedlander AL, Genant HK, Sadowsky S, Byl NN, and Gluer CC. A two-year program of aerobics and weight training enhances bone mineral density of young women. *J Bone Miner Res* 1995;10(4):574-585.
75. Frost HM. Bone "mass" and the "mechanostat": a proposal. *Anat Rec* 1987;219(1):1-9.
76. Frost HM. The mechanostat: a proposed pathogenic mechanism of osteoporoses and the bone mass effects of mechanical and nonmechanical agents. *Bone Miner* 1987;2(2):73-85.
77. Frost HM. From Wolff's law to the mechanostat: a new "face" of physiology. *J Orthop Sci* 1998;3(5):282-286.
78. Frost HM. Emerging views about "osteoporosis", bone health, strength, fragility, and their determinants. *J Bone Miner Metab* 2002;20(6):319-325.
79. Gafni RI, and Baron J. Childhood bone mass acquisition and peak bone mass may not be important determinants of bone mass in late adulthood. *Pediatrics* 2007;119 Suppl 2:S131-136.
80. Gerstman BB. *Epidemiology kept simple : an introduction to traditional and modern epidemiology*. 2nd ed. Hoboken, N.J.: Wiley-Liss; 2003.
81. Greendale GA, Barrett-Connor E, Edelstein S, Ingles S, and Haile R. Lifetime leisure exercise and osteoporosis. The Rancho Bernardo study. *Am J Epidemiol* 1995;141(10):951-959.
82. Gregg EW, Cauley JA, Seeley DG, Ensrud KE, and Bauer DC. Physical activity and osteoporotic fracture risk in older women. Study of Osteoporotic Fractures Research Group. *Ann Intern Med* 1998;129(2):81-88.
83. Gronholz MJ. Prevention, diagnosis, and management of osteoporosis-related fracture: a multifactoral osteopathic approach. *J Am Osteopath Assoc* 2008;108(10):575-585.
84. Guadalupe-Grau A, Fuentes T, Guerra B, and Calbet JA. Exercise and bone mass in adults. *Sports Med* 2009;39(6):439-468.
85. Gullberg B, Johnell O, and Kanis JA. World-wide projections for hip fracture. *Osteoporos Int* 1997;7(5):407-413.
86. Gunter K, Baxter-Jones AD, Mirwald RL, Almstedt H, Fuller A, Durski S, and Snow C. Jump starting skeletal health: a 4-year longitudinal study assessing the effects of jumping on skeletal development in pre and circum pubertal children. *Bone* 2008;42(4):710-718.
87. Hamilton CJ, Swan VJ, and Jamal SA. The effects of exercise and physical activity participation on bone mass and geometry in postmenopausal women: a systematic review of pQCT studies. *Osteoporos Int* 2010;21(1):11-23.

88. Hardman AE, and Stensel DJ. *Physical activity and health : the evidence explained*. 2nd ed. London ; New York: Routledge; 2009.
89. Haskell WL, Lee IM, Pate RR, Powell KE, Blair SN, Franklin BA, Macera CA, Heath GW, Thompson PD, and Bauman A. Physical activity and public health: updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. *Med Sci Sports Exerc* 2007;39(8):1423-1434.
90. Heaney RP, Abrams S, Dawson-Hughes B, Looker A, Marcus R, Matkovic V, and Weaver C. Peak bone mass. *Osteoporos Int* 2000;11(12):985-1009.
91. Heinonen A, Kannus P, Sievanen H, Oja P, Pasanen M, Rinne M, Uusi-Rasi K, and Vuori I. Randomised controlled trial of effect of high-impact exercise on selected risk factors for osteoporotic fractures. *Lancet* 1996;348(9038):1343-1347.
92. Heinonen A, Oja P, Kannus P, Sievanen H, Haapasalo H, Manttari A, and Vuori I. Bone mineral density in female athletes representing sports with different loading characteristics of the skeleton. *Bone* 1995;17(3):197-203.
93. Henderson M, and Page L. Appraising the evidence: what is selection bias? *Evid Based Ment Health* 2007;10(3):67-68.
94. Hind K, and Burrows M. Weight-bearing exercise and bone mineral accrual in children and adolescents: a review of controlled trials. *Bone* 2007;40(1):14-27.
95. Honkanen RJ, Honkanen K, Kröger H, Alhava E, Tuppurainen M, and Saarikoski S. Risk factors for perimenopausal distal forearm fracture. *Osteoporos Int* 2000;11:265-270.
96. Huddleston AL, Rockwell D, Kulund DN, and Harrison RB. Bone mass in lifetime tennis athletes. *JAMA* 1980;244(10):1107-1109.
97. Høidrup S, Sorensen TI, Stroger U, Lauritzen JB, Schroll M, and Gronbaek M. Leisure-time physical activity levels and changes in relation to risk of hip fracture in men and women. *Am J Epidemiol* 2001;154(1):60-68.
98. Haapasalo H, Kannus P, Sievanen H, Heinonen A, Oja P, and Vuori I. Long-term unilateral loading and bone mineral density and content in female squash players. *Calcif Tissue Int* 1994;54(4):249-255.
99. Haapasalo H, Sievanen H, Kannus P, Heinonen A, Oja P, and Vuori I. Dimensions and estimated mechanical characteristics of the humerus after long-term tennis loading. *J Bone Miner Res* 1996;11(6):864-872.
100. Haase A, Steptoe A, Sallis JF, and Wardle J. Leisure-time physical activity in university students from 23 countries: associations with health beliefs, risk awareness, and national economic development. *Prev Med* 2004;39(1):182-190.
101. Ilich-Ernst J, Brownbill RA, Ludemann MA, and Fu R. Critical factors for bone health in women across the age span: how important is muscle mass? *Medscape women's health* 2002;7(3):2.

102. Ivers RQ, Cumming RG, Mitchell P, and Peduto AJ. Risk factors for fractures of the wrist, shoulder and ankle: the Blue Mountains Eye Study. *Osteoporos Int* 2002;13:513-518.
103. Jacobsen BK, Eggen AE, Mathiesen EB, Wilsgaard T, and Njølstad I. Cohort profile: The Tromsø Study. *Int J Epidemiol* 2011.
104. Jarvinen TL, Sievanen H, Khan KM, Heinonen A, and Kannus P. Shifting the focus in fracture prevention from osteoporosis to falls. *BMJ* 2008;336(7636):124-126.
105. Joakimsen RM, Fønnebø V, Magnus JH, Størmer J, Tollan A, and Søgaard AJ. The Tromsø Study: physical activity and the incidence of fractures in a middle-aged population. *J Bone Miner Res* 1998;13(7):1149-1157.
106. Joakimsen RM, Fønnebø V, Søgaard AJ, Tollan A, Størmer J, and Magnus JH. The Tromsø study: registration of fractures, how good are self-reports, a computerized radiographic register and a discharge register? *Osteoporos Int* 2001;12(12):1001-1005.
107. Johnell O, and Kanis J. Epidemiology of osteoporotic fractures. *Osteoporos Int* 2005;16 Suppl 2:S3-7.
108. Johnell O, and Kanis JA. An estimate of the worldwide prevalence and disability associated with osteoporotic fractures. *Osteoporos Int* 2006;17(12):1726-1733.
109. Johnell O, Kanis JA, Oden A, Johansson H, De Laet C, Delmas P, Eisman JA, Fujiwara S, Kroger H, Mellstrom D, Meunier PJ, Melton LJ, 3rd, O'Neill T, Pols H, Reeve J, Silman A, and Tenenhouse A. Predictive value of BMD for hip and other fractures. *J Bone Miner Res* 2005;20(7):1185-1194.
110. Jones G, Nguyen T, Sambrook P, Kelly PJ, and Eisman JA. Progressive loss of bone in the femoral neck in elderly people: longitudinal findings from the Dubbo osteoporosis epidemiology study. *BMJ* 1994;309(6956):691-695.
111. Jones HH, Priest JD, Hayes WC, Tichenor CC, and Nagel DA. Humeral hypertrophy in response to exercise. *J Bone Joint Surg Am* 1977;59(2):204-208.
112. Judex S, and Carlson KJ. Is bone's response to mechanical signals dominated by gravitational loading? *Med Sci Sports Exerc* 2009;41:2037-2043.
113. Judex S, Gupta S, and Rubin C. Regulation of mechanical signals in bone. *Orthod Craniofac Res* 2009;12(2):94-104.
114. Judex S, and Rubin C. Mechanical Influences on Bone Mass and Morphology. In: RA Adler editor. *Osteoporosis*. Humana Press; 2010, pp. 181-205.
115. Jørgensen L, Morseth B, Andreassen M, and Jacobsen B. Comments to Emaus et al. "Does a variation in self-reported physical activity reflect variation in objectively measured physical activity, resting heart rate, and physical fitness? Results from the Tromsø study". *Scand J Public Health* 2011;39:437-438.
116. Kanis JA. An update on the diagnosis of osteoporosis. *Curr Rheumatol Rep* 2000;2(1):62-66.
117. Kanis JA. Diagnosis of osteoporosis and assessment of fracture risk. *Lancet* 2002;359(9321):1929-1936.

118. Kanis JA, Borgstrom F, De Laet C, Johansson H, Johnell O, Jonsson B, Oden A, Zethraeus N, Pfleger B, and Khaltaev N. Assessment of fracture risk. *Osteoporos Int* 2005;16(6):581-589.
119. Kanis JA, Johnell O, Oden A, De Laet C, and Mellstrom D. Diagnosis of osteoporosis and fracture threshold in men. *Calcif Tissue Int* 2001;69(4):218-221.
120. Kanis JA, Johnell O, Oden A, De Laet C, and Mellstrom D. Epidemiology of osteoporosis and fracture in men. *Calcif Tissue Int* 2004;75(2):90-99.
121. Kanis JA, Johnell O, Oden A, Johansson H, and McCloskey E. FRAXtrade mark and the assessment of fracture probability in men and women from the UK. *Osteoporos Int* 2008;19(4):385-397.
122. Kanis JA, McCloskey EV, Johansson H, Oden A, Melton LJ, 3rd, and Khaltaev N. A reference standard for the description of osteoporosis. *Bone* 2008;42(3):467-475.
123. Kannus P, Haapasalo H, Sankelo M, Sievanen H, Pasanen M, Heinonen A, Oja P, and Vuori I. Effect of starting age of physical activity on bone mass in the dominant arm of tennis and squash players. *Ann Intern Med* 1995;123(1):27-31.
124. Kannus P, Niemi S, Parkkari J, Palvanen M, Vuori I, and Jarvinen M. Nationwide decline in incidence of hip fracture. *J Bone Miner Res* 2006;21(12):1836-1838.
125. Kannus P, Uusi-Rasi K, Palvanen M, and Parkkari J. Non-pharmacological means to prevent fractures among older adults. *Ann Med* 2005;37(4):303-310.
126. Karlsson MK. Physical activity, skeletal health and fractures in a long term perspective. *J Musculoskelet Neuronal Interact* 2004;4(1):12-21.
127. Karlsson MK, Hasserius R, and Obrant KJ. Bone mineral density in athletes during and after career: a comparison between loaded and unloaded skeletal regions. *Calcif Tissue Int* 1996;59(4):245-248.
128. Karlsson MK, Johnell O, and Obrant KJ. Bone mineral density in professional ballet dancers. *Bone Miner* 1993;21(3):163-169.
129. Karlsson MK, Johnell O, and Obrant KJ. Bone mineral density in weight lifters. *Calcif Tissue Int* 1993;52(3):212-215.
130. Karlsson MK, Johnell O, and Obrant KJ. Is bone mineral density advantage maintained long-term in previous weight lifters? *Calcif Tissue Int* 1995;57(5):325-328.
131. Karlsson MK, Linden C, Karlsson C, Johnell O, Obrant K, and Seeman E. Exercise during growth and bone mineral density and fractures in old age. *Lancet* 2000;355(9202):469-470.
132. Karlsson MK, Nordqvist A, and Karlsson C. Physical activity increases bone mass during growth. *Food Nutr Res* 2008;52.
133. Karlsson MK, Nordqvist A, and Karlsson C. Physical activity, muscle function, falls and fractures. *Food Nutr Res* 2008;52.
134. Karlsson MK, Nordqvist A, and Karlsson C. Sustainability of exercise-induced increases in bone density and skeletal structure. *Food Nutr Res* 2008;52.

135. Karlsson MK, Obrant KJ, Nilsson BE, and Johnell O. Changes in bone mineral, lean body mass and fat content as measured by dual energy X-ray absorptiometry: a longitudinal study. *Calcif Tissue Int* 2000;66(2):97-99.

136. Kelley G. Aerobic exercise and lumbar spine bone mineral density in postmenopausal women: a meta-analysis. *J Am Geriatr Soc* 1998;46(2):143–152.

137. Kelley GA. Exercise and regional bone mineral density in postmenopausal women: a meta-analytic review of randomized trials. *American journal of physical medicine & rehabilitation / Association of Academic Physiatrists* 1998;77(1):76-87.

138. Kelley GA, and Kelley KS. Exercise and bone mineral density at the femoral neck in postmenopausal women: a meta-analysis of controlled clinical trials with individual patient data. *Am J Obstet Gynecol* 2006;194(3):760-767.

139. Kelley GA, Kelley KS, and Tran ZV. Exercise and bone mineral density in men: a meta-analysis. *J Appl Physiol* 2000;88(5):1730-1736.

140. Kelsey JL, Browner WS, Seeley DG, Nevitt MC, and Cummings SR. Risk factors for fractures of the distal forearm and proximal humerus. The Study of Osteoporotic Fractures Research Group. *Am J Epidemiol* 1992;135(5):477-489.

141. Kemper HC, Twisk JW, van Mechelen W, Post GB, Roos JC, and Lips P. A fifteen-year longitudinal study in young adults on the relation of physical activity and fitness with the development of the bone mass: The Amsterdam Growth And Health Longitudinal Study. *Bone* 2000;27(6):847-853.

142. Keyak JH, Koyama AK, LeBlanc A, Lu Y, and Lang TF. Reduction in proximal femoral strength due to long-duration spaceflight. *Bone* 2009;44(3):449-453.

143. Khan K. *Physical activity and bone health*. Champaign, IL: Human Kinetics; 2001.

144. Kirjonen J, Telama R, Luukkonen R, Kaaria S, Kaila-Kangas L, and Leino-Arjas P. Stability and prediction of physical activity in 5-, 10-, and 28-year follow-up studies among industrial employees. *Scand J Med Sci Sports* 2006;16(3):201-208.

145. Kohrt WM, Barry DW, and Schwartz RS. Muscle forces or gravity: What predominates mechanical loading on bone? *Med Sci Sports Exerc* 2009;41(11):2050-2055.

146. Kohrt WM, Bloomfield SA, Little KD, Nelson ME, Yingling VR, and American College of Sports M. American College of Sports Medicine Position Stand: physical activity and bone health. *Med Sci Sports Exerc* 2004;36(11):1985-1996.

147. Kokkinos P. Physical activity and cardiovascular disease prevention: current recommendations. *Angiology* 2008;59(2 Suppl):26S-29S.

148. Kolbe-Alexander TL, Charlton KE, and Lambert EV. Lifetime physical activity and determinants of estimated bone mineral density using calcaneal ultrasound in older South African adults. *J Nutr Health Aging* 2004;8(6):521-530.

149. Korpelainen R, Keinanen-Kiukaanniemi S, Heikkinen J, Vaananen K, and Korpelainen J. Effect of impact exercise on bone mineral density in elderly women with low BMD: a population-based randomized controlled 30-month intervention. *Osteoporos Int* 2006;17(1):109-118.

150. Kriska AM, Sandler RB, Cauley JA, LaPorte RE, Hom DL, and Pambianco G. The assessment of historical physical activity and its relation to adult bone parameters. *Am J Epidemiol* 1988;127(5):1053-1063.

151. Kujala UM, Kaprio J, Kannus P, Sarna S, and Koskenvuo M. Physical activity and osteoporotic hip fracture risk in men. *Arch Intern Med* 2000;160(5):705-708.

152. Kurtze N GK, Holmen J. Selvrapportert fysisk aktivitet i norske befolkningsundersøkelser - et metodeproblem. *Norsk Epidemiol* 2003;13:163-170.

153. Kurtze N, Rangul V, Hustvedt BE, and Flanders WD. Reliability and validity of self-reported physical activity in the Nord-Trøndelag Health Study (HUNT 2). *Eur J Epidemiol* 2007;22(6):379-387.

154. Lang TF. What do we know about fracture risk in long-duration spaceflight? *J Musculoskelet Neuronal Interact* 2006;6(4):319-321.

155. Lang TF, Leblanc AD, Evans HJ, and Lu Y. Adaptation of the proximal femur to skeletal reloading after long-duration spaceflight. *J Bone Miner Res* 2006;21(8):1224-1230.

156. Lanyon LE. Osteocytes, strain detection, bone modeling and remodeling. *Calcif Tissue Int* 1993;53 Suppl 1:S102-106; discussion S106-107.

157. Lanyon LE, and Rubin CT. Static vs dynamic loads as an influence on bone remodelling. *J Biomech* 1984;17(12):897-905.

158. Larsen OA, and Malmborg RO. *Coronary heart disease and physical fitness; proceedings*. [1st ed. Baltimore,: University Park Press; 1971.

159. Leblanc AD, Schneider VS, Evans HJ, Engelbretson DA, and Krebs JM. Bone mineral loss and recovery after 17 weeks of bed rest. *J Bone Miner Res* 1990;5(8):843-850.

160. LeBlanc AD, Spector ER, Evans HJ, and Sibonga JD. Skeletal responses to space flight and the bed rest analog: a review. *J Musculoskelet Neuronal Interact* 2007;7(1):33-47.

161. Lee IM. *Epidemiologic methods in physical activity studies*. Oxford: Oxford University Press; 2009.

162. Lee IM, Paffenbarger RS, Jr., and Hsieh CC. Time trends in physical activity among college alumni, 1962-1988. *Am J Epidemiol* 1992;135(8):915-925.

163. Lefevre J, Philippaerts RM, Delvaux K, Thomis M, Vanreusel B, Eynde BV, Claessens AL, Lysens R, Renson R, and Beunen G. Daily physical activity and physical fitness from adolescence to adulthood: A longitudinal study. *Am J Hum Biol* 2000;12(4):487-497.

164. Linden C, Ahlborg HG, Besjakov J, Gardsell P, and Karlsson MK. A school curriculum-based exercise program increases bone mineral accrual and bone size in prepubertal girls: two-year data from the pediatric osteoporosis prevention (POP) study. *J Bone Miner Res* 2006;21(6):829-835.

165. Linden C, Alwis G, Ahlborg H, Gardsell P, Valdimarsson O, Stenevi-Lundgren S, Besjakov J, and Karlsson MK. Exercise, bone mass and bone size in prepubertal boys: one-year data from the pediatric osteoporosis prevention study. *Scand J Med Sci Sports* 2007;17(4):340-347.
166. Lofthus CM, Osnes EK, Falch JA, Kaastad TS, Kristiansen IS, Nordsletten L, Stensvold I, and Meyer HE. Epidemiology of hip fractures in Oslo, Norway. *Bone* 2001;29(5):413-418.
167. Lohman T, Going S, Pamenter R, Hall M, Boyden T, Houtkooper L, Ritenbaugh C, Bare L, Hill A, and Aickin M. Effects of resistance training on regional and total bone mineral density in premenopausal women: a randomized prospective study. *J Bone Miner Res* 1995;10(7):1015-1024.
168. Lynch NA, Ryan AS, Evans J, Katzel LI, and Goldberg AP. Older elite football players have reduced cardiac and osteoporosis risk factors. *Med Sci Sports Exerc* 2007;39(7):1124-1130.
169. MacKelvie KJ, Khan KM, Petit MA, Janssen PA, and McKay HA. A school-based exercise intervention elicits substantial bone health benefits: a 2-year randomized controlled trial in girls. *Pediatrics* 2003;112(6 Pt 1):e447.
170. Mackey DC, Hubbard AE, Cawthon PM, Cauley JA, Cummings SR, and Tager IB. Usual physical activity and hip fracture in older men: an application of semiparametric methods to observational data. *Am J Epidemiol* 2011;173(5):578-586.
171. Marshall D, Johnell O, and Wedel H. Meta-analysis of how well measures of bone mineral density predict occurrence of osteoporotic fractures. *BMJ* 1996;312(7041):1254-1259.
172. Martyn-St James M, and Carroll S. High-intensity resistance training and postmenopausal bone loss: a meta-analysis. *Osteoporos Int* 2006;17(8):1225-1240.
173. Martyn-St James M, and Carroll S. Progressive high-intensity resistance training and bone mineral density changes among premenopausal women: evidence of discordant site-specific skeletal effects. *Sports Med* 2006;36(8):683-704.
174. Martyn-St James M, and Carroll S. Meta-analysis of walking for preservation of bone mineral density in postmenopausal women. *Bone* 2008;43(3):521-531.
175. Martyn-St James M, and Carroll S. A meta-analysis of impact exercise on postmenopausal bone loss: the case for mixed loading exercise programmes. *Br J Sports Med* 2009;43(12):898-908.
176. Martyn-St James M, and Carroll S. Effects of different impact exercise modalities on bone mineral density in premenopausal women: a meta-analysis. *J Bone Miner Metab* 2010;28(3):251-267.
177. Matton L, Thomis M, Wijndaele K, Duvigneaud N, Beunen G, Claessens AL, Vanreusel B, Philippaerts R, and Lefevre J. Tracking of physical fitness and physical activity from youth to adulthood in females. *Med Sci Sports Exerc* 2006;38(6):1114-1120.
178. Mazess RB, Barden HS, Drinka PJ, Bauwens SF, Orwoll ES, and Bell NH. Influence of age and body weight on spine and femur bone mineral density in U.S. white men. *J Bone Miner Res* 1990;5(6):645-652.

179. McKay HA, Petit MA, Schutz RW, Prior JC, Barr SI, and Khan KM. Augmented trochanteric bone mineral density after modified physical education classes: a randomized school-based exercise intervention study in prepubescent and early pubescent children. *J Pediatr* 2000;136(2):156-162.

180. Mein AL, Briffa NK, Dhaliwal SS, and Price RI. Lifestyle influences on 9-year changes in BMD in young women. *J Bone Miner Res* 2004;19(7):1092-1098.

181. Menkes A, Mazel S, Redmond RA, Koffler K, Libanati CR, Gundberg CM, Zizic TM, Hagberg JM, Pratley RE, and Hurley BF. Strength training increases regional bone mineral density and bone remodeling in middle-aged and older men. *J Appl Physiol* 1993;74(5):2478-2484.

182. Meyer HE, Berntsen GK, Søgaard AJ, Langhammer A, Schei B, Fønnebø V, Forsmo S, and Tell GS. Higher bone mineral density in rural compared with urban dwellers: the NOREPOS study. *Am J Epidemiol* 2004;160(11):1039-1046.

183. Meyer HE, Henriksen C, Falch JA, Pedersen JI, and Tverdal A. Risk factors for hip fracture in a high incidence area: a case-control study from Oslo, Norway. *Osteoporos Int* 1995;5(4):239-246.

184. Michaelsson K, Olofsson H, Jensevik K, Larsson S, Mallmin H, Berglund L, Vessby B, and Melhus H. Leisure physical activity and the risk of fracture in men. *PLoS Med* 2007;4(6):e199.

185. Moayyeri A. The association between physical activity and osteoporotic fractures: a review of the evidence and implications for future research. *Ann Epidemiol* 2008;18(11):827-835.

186. Moayyeri A, Besson H, Luben RN, Wareham NJ, and Khaw KT. The association between physical activity in different domains of life and risk of osteoporotic fractures. *Bone* 2010;47(3):693-700.

187. Morris FL, Naughton GA, Gibbs JL, Carlson JS, and Wark JD. Prospective ten-month exercise intervention in premenarcheal girls: positive effects on bone and lean mass. *J Bone Miner Res* 1997;12(9):1453-1462.

188. Morrow JR, Jr., Bain TM, Frierson GM, Trudelle-Jackson E, and Haskell WL. Long-term tracking of physical activity behaviors in women: the WIN Study. *Med Sci Sports Exerc* 2011;43(1):165-170.

189. Mudd LM, Fornetti W, and Pivarnik JM. Bone mineral density in collegiate female athletes: comparisons among sports. *J Athl Train* 2007;42(3):403-408.

190. Mussolino ME, Looker AC, Madans JH, Langlois JA, and Orwoll ES. Risk factors for hip fracture in white men: the NHANES I Epidemiologic Follow-up Study. *J Bone Miner Res* 1998;13(6):918-924.

191. Mussolino ME, Looker AC, and Orwoll ES. Jogging and bone mineral density in men: results from NHANES III. *Am J Public Health* 2001;91(7):1056-1059.

192. National Osteoporosis Foundation. Osteoporosis: review of the evidence for prevention, diagnosis and treatment and cost-effectiveness analysis. Introduction. *Osteoporos Int* 1998;8 Suppl 4:S7-80.

193. Nelson ME, Fiatarone MA, Morganti CM, Trice I, Greenberg RA, and Evans WJ. Effects of high-intensity strength training on multiple risk factors for osteoporotic fractures. A randomized controlled trial. *JAMA* 1994;272(24):1909-1914.

194. Nguyen TV, Eisman JA, Kelly PJ, and Sambrook PN. Risk factors for osteoporotic fractures in elderly men. *Am J Epidemiol* 1996;144(3):255-263.

195. Nikander R, Gagnon C, Dunstan DW, Magliano DJ, Ebeling PR, Lu ZX, Zimmet PZ, Shaw JE, and Daly RM. Frequent walking, but not total physical activity, is associated with increased fracture incidence: A 5-year follow-up of an Australian population based prospective study (AusDiab). *J Bone Miner Res* 2011;Feb 15. doi: 10.1002/jbmr.363. [Epub ahead of print].

196. Nikander R, Sievanen H, Heinonen A, Daly RM, Uusi-Rasi K, and Kannus P. Targeted exercise against osteoporosis: A systematic review and meta-analysis for optimising bone strength throughout life. *BMC Med* 2010;8:47.

197. Nikander R, Sievanen H, Heinonen A, and Kannus P. Femoral neck structure in adult female athletes subjected to different loading modalities. *J Bone Miner Res* 2005;20(3):520-528.

198. Nilsson M, Ohlsson C, Eriksson AL, Frandin K, Karlsson M, Ljunggren O, Mellström D, and Lorentzon M. Competitive physical activity early in life is associated with bone mineral density in elderly Swedish men. *Osteoporos Int* 2008;19(11):1557-1566.

199. Nordström A, Olsson T, and Nordström P. Sustained benefits from previous physical activity on bone mineral density in males. *J Clin Endocrinol Metab* 2006;91(7):2600-2604.

200. Nortvedt MW, Riise T, and Mæland JG. Multiple sclerosis and lifestyle factors: the Hordaland Health Study. *Neurol Sci* 2005;26(5):334-339.

201. Nurmi-Lawton JA, Baxter-Jones AD, Mirwald RL, Bishop JA, Taylor P, Cooper C, and New SA. Evidence of sustained skeletal benefits from impact-loading exercise in young females: a 3-year longitudinal study. *J Bone Miner Res* 2004;19(2):314-322.

202. Olszynski WP, Shawn Davison K, Adachi JD, Brown JP, Cummings SR, Hanley DA, Harris SP, Hodsman AB, Kendler D, McClung MR, Miller PD, and Yuen CK. Osteoporosis in men: epidemiology, diagnosis, prevention, and treatment. *Clin Ther* 2004;26(1):15-28.

203. Omsland TK, Ahmed LA, Grønskag A, Schei B, Emaus N, Langhammer A, Joakimsen RM, Jørgensen L, Søgaard AJ, Gjesdal CG, and Meyer HE. More forearm fractures among urban than rural women: The NOREPOS study based on the Tromsø study and the HUNT study. *J Bone Miner Res* 2011;26(4):850-856.

204. Omsland TK, Emaus N, Gjesdal CG, Falch JA, Tell GS, Forsen L, Berntsen GK, and Meyer HE. In vivo and in vitro comparison of densitometers in the NOREPOS study. *J Clin Densitom* 2008;11(2):276-282.

205. Paffenbarger RS, Jr., and Hyde RT. Exercise in the prevention of coronary heart disease. *Prev Med* 1984;13(1):3-22.

206. Paganini-Hill A, Chao A, Ross RK, and Henderson BE. Exercise and other factors in the prevention of hip fracture: the Leisure World study. *Epidemiology* 1991;2(1):16-25.

207. Page LA, and Henderson M. Appraising the evidence: what is measurement bias? *Evid Based Ment Health* 2008;11(2):36-37.

208. Picavet HS, Wendel-vos GC, Vreeken HL, Schuit AJ, and Verschuren WM. How stable are physical activity habits among adults? The Doetinchem Cohort Study. *Med Sci Sports Exerc* 2011;43(1):74-79.
209. Pollock NK, Laing EM, Modlesky CM, O'Connor PJ, and Lewis RD. Former college artistic gymnasts maintain higher BMD: a nine-year follow-up. *Osteoporos Int* 2006;17(11):1691-1697.
210. Porta M, Last JM, Greenland S, and International Epidemiological Association. *A Dictionary of epidemiology*. 5th ed. Oxford: Oxford University Press; 2008.
211. Reginster JY, Sarlet N, and Lecart MP. Fractures in osteoporosis: the challenge for the new millennium. *Osteoporos Int* 2005;16 Suppl 1:S1-3.
212. Riddle RC, and Donahue HJ. From streaming-potentials to shear stress: 25 years of bone cell mechanotransduction. *J Orthop Res* 2009;27(2):143-149.
213. Rideout CA, McKay HA, and Barr SI. Self-reported lifetime physical activity and areal bone mineral density in healthy postmenopausal women: the importance of teenage activity. *Calcif Tissue Int* 2006;79(4):214-222.
214. Rikkonen T, Salovaara K, Sirola J, Karkkainen M, Tuppurainen M, Jurvelin J, Honkanen R, Alhava E, and Kroger H. Physical activity slows femoral bone loss but promotes wrist fractures in postmenopausal women: a 15-year follow-up of the OSTPRE study. *J Bone Miner Res* 2010;25(11):2332-2340.
215. Rizzoli R, Bonjour JP, and Ferrari SL. Osteoporosis, genetics and hormones. *J Mol Endocrinol* 2001;26(2):79-94.
216. Robbins J, Aragaki AK, Kooperberg C, Watts N, Wactawski-Wende J, Jackson RD, LeBoff MS, Lewis CE, Chen Z, Stefanick ML, and Cauley J. Factors associated with 5-year risk of hip fracture in postmenopausal women. *JAMA* 2007;298(20):2389-2398.
217. Robling AG, Castillo AB, and Turner CH. Biomechanical and molecular regulation of bone remodeling. *Annu Rev Biomed Eng* 2006;8:455-498.
218. Robling AG, Hinant FM, Burr DB, and Turner CH. Improved bone structure and strength after long-term mechanical loading is greatest if loading is separated into short bouts. *J Bone Miner Res* 2002;17(8):1545-1554.
219. Rosengren A, and Wilhelmsen L. Physical activity protects against coronary death and deaths from all causes in middle-aged men. Evidence from a 20-year follow-up of the primary prevention study in Goteborg. *Ann Epidemiol* 1997;7(1):69-75.
220. Rosvold Berntsen GK, Fønnebø V, Tollan A, Søgaard AJ, Joakimsen RM, and Magnus JH. The Tromsø study: determinants of precision in bone densitometry. *J Clin Epidemiol* 2000;53(11):1104-1112.
221. Rothman KJ. *Epidemiology : an introduction*. New York, N.Y.: Oxford University Press; 2002.
222. Rubin CT, and Lanyon LE. Regulation of bone formation by applied dynamic loads. *J Bone Joint Surg Am* 1984;66(3):397-402.

223. Sallis JF, Greenlee L, McKenzie TL, Broyles SL, Zive MM, Berry CC, Brennan J, and Nader PR. Changes and tracking of physical activity across seven years in Mexican-American and European-American mothers. *Women Health* 2001;34(4):1-14.

224. Saltin B, and Grimby G. Physiological analysis of middle-aged and old former athletes. Comparison with still active athletes of the same ages. *Circulation* 1968;38(6):1104-1115.

225. Scott A, Khan KM, Duronio V, and Hart DA. Mechanotransduction in human bone: in vitro cellular physiology that underpins bone changes with exercise. *Sports Med* 2008;38(2):139-160.

226. Seeman E. Pathogenesis of bone fragility in women and men. *Lancet* 2002;359(9320):1841-1850.

227. Seeman E, Bianchi G, Adami S, Kanis J, Khosla S, and Orwoll E. Osteoporosis in men--consensus is premature. *Calcif Tissue Int* 2004;75(2):120-122.

228. Sernbo I, and Johnell O. Consequences of a hip fracture: a prospective study over 1 year. *Osteoporos Int* 1993;3(3):148-153.

229. Shea B, Bonaiuti D, Iovine R, Negrini S, Robinson V, Kemper HC, Wells G, Tugwell P, and Cranney A. Cochrane Review on exercise for preventing and treating osteoporosis in postmenopausal women. *Eura Medicophys* 2004;40(3):199-209.

230. Shipp KM. Exercise for people with osteoporosis: translating the science into clinical practice. *Curr Osteoporos Rep* 2006;4(4):129-133.

231. Silva MJ. Biomechanics of osteoporotic fractures. *Injury* 2007;38 Suppl 3:S69-76.

232. Sisson SB, and Katzmarzyk PT. International prevalence of physical activity in youth and adults. *Obes Rev* 2008;9(6):606-614.

233. Sjøl A, Thomsen KK, Schroll M, and Andersen LB. Secular trends in acute myocardial infarction in relation to physical activity in the general Danish population. *Scand J Med Sci Sports* 2003;13(4):224-230.

234. Skerry TM. One mechanostat or many? Modifications of the site-specific response of bone to mechanical loading by nature and nurture. *J Musculoskelet Neuronal Interact* 2006;6(2):122-127.

235. Skerry TM. The response of bone to mechanical loading and disuse: fundamental principles and influences on osteoblast/osteocyte homeostasis. *Arch Biochem Biophys* 2008;473(2):117-123.

236. Snow-Harter C, Bouxsein ML, Lewis BT, Carter DR, and Marcus R. Effects of resistance and endurance exercise on bone mineral status of young women: a randomized exercise intervention trial. *J Bone Miner Res* 1992;7(7):761-769.

237. SPSS Technical Support Web site. Weighted kappa syntax for SPSS. http://support.spss.com/student/Troubleshooting/sturessearchdetail.asp?ID=24999. Chicago (IL): SPSS Inc.; 2010.

238. Stone KL, Seeley DG, Lui LY, Cauley JA, Ensrud K, Browner WS, Nevitt MC, and Cummings SR. BMD at multiple sites and risk of fracture of multiple types: long-term results from the Study of Osteoporotic Fractures. *J Bone Miner Res* 2003;18(11):1947-1954.

239. Ström O, Borgström F, Kanis J, Compston J, Cooper C, Stenmark J, McKloskey E, Oden A, Johansson H, Olson M, and Jönsson B. The Burden of Fractures in France, Germany, Italy, Spain, Sweden, and the UK. *Osteoporos Int* 2011;22(S1):97-117.

240. Søgaard AJ, Gustad TK, Bjertness E, Tell GS, Schei B, Emaus N, and Meyer HE. Urban-rural differences in distal forearm fractures: Cohort Norway. *Osteoporos Int* 2007;18(8):1063-1072.

241. Taylor W, Øyane NM, Ursin R, Pallesen S, Holsten F, and Bjorvatn B. Increased Health Risk in Subjects with High Self-Reported Seasonality. *PLoS ONE* 2010;5(3):e9498.

242. Telama R, Yang X, Viikari J, Valimaki I, Wanne O, and Raitakari O. Physical activity from childhood to adulthood: a 21-year tracking study. *Am J Prev Med* 2005;28(3):267-273.

243. Temiyasathit S, and Jacobs CR. Osteocyte primary cilium and its role in bone mechanotransduction. *Ann N Y Acad Sci* 2010;1192(1):422-428.

244. Thorpe DL, Knutsen SF, Beeson WL, and Fraser GE. The effect of vigorous physical activity and risk of wrist fracture over 25 years in a low-risk survivor cohort. *J Bone Miner Metab* 2006;24(6):476-483.

245. Thorsen L, Nystad W, Stigum H, Dahl O, Klepp O, Bremnes RM, Wist E, and Fosså SD. The association between self-reported physical activity and prevalence of depression and anxiety disorder in long-term survivors of testicular cancer and men in a general population sample. *Support Care Cancer* 2005;13(8):637-646.

246. Thune I, and Furberg AS. Physical activity and cancer risk: dose-response and cancer, all sites and site-specific. *Med Sci Sports Exerc* 2001;33(6 Suppl):S530-550; discussion S609-510.

247. Torstveit MK. [Bone adaptation to mechanical loading]. *Tidsskr Nor Laegeforen* 2002;122(21):2109-2111.

248. Trimpou P, Landin-Wilhelmsen K, Oden A, Rosengren A, and Wilhelmsen L. Male risk factors for hip fracture-a 30-year follow-up study in 7,495 men. *Osteoporos Int* 2010;21(3):409-416.

249. Trudeau F, Laurencelle L, and Shephard RJ. Tracking of physical activity from childhood to adulthood. *Med Sci Sports Exerc* 2004;36(11):1937-1943.

250. Turner CH. Homeostatic control of bone structure: an application of feedback theory. *Bone* 1991;12(3):203-217.

251. Turner CH, and Burr DB. Basic biomechanical measurements of bone: a tutorial. *Bone* 1993;14(4):595-608.

252. Turner CH, Forwood MR, and Otter MW. Mechanotransduction in bone: do bone cells act as sensors of fluid flow? *FASEB J* 1994;8(11):875-878.

253. Turner CH, Owan I, and Takano Y. Mechanotransduction in bone: role of strain rate. *Am J Physiol* 1995;269(3 Pt 1):E438-442.

254. Turner CH, and Pavalko FM. Mechanotransduction and functional response of the skeleton to physical stress: the mechanisms and mechanics of bone adaptation. *J Orthop Sci* 1998;3(6):346-355.

255. Twisk JW, Staal BJ, Brinkman MN, Kemper HC, and van Mechelen W. Tracking of lung function parameters and the longitudinal relationship with lifestyle. *Eur Respir J* 1998;12(3):627-634.
256. Umemura Y, Ishiko T, Yamauchi T, Kurono M, and Mashiko S. Five jumps per day increase bone mass and breaking force in rats. *J Bone Miner Res* 1997;12(9):1480-1485.
257. Uusi-Rasi K, Kannus P, Cheng S, Sievanen H, Pasanen M, Heinonen A, Nenonen A, Halleen J, Fuerst T, Genant H, and Vuori I. Effect of alendronate and exercise on bone and physical performance of postmenopausal women: a randomized controlled trial. *Bone* 2003;33(1):132-143.
258. Uzunca K, Birtane M, Durmus-Altun G, and Ustun F. High bone mineral density in loaded skeletal regions of former professional football (soccer) players: what is the effect of time after active career? *Br J Sports Med* 2005;39(3):154-157.
259. Vainionpaa A, Korpelainen R, Leppaluoto J, and Jamsa T. Effects of high-impact exercise on bone mineral density: a randomized controlled trial in premenopausal women. *Osteoporos Int* 2005;16(2):191-197.
260. Valdimarsson O, Linden C, Johnell O, Gardsell P, and Karlsson MK. Daily physical education in the school curriculum in prepubertal girls during 1 year is followed by an increase in bone mineral accrual and bone width--data from the prospective controlled Malmo pediatric osteoporosis prevention study. *Calcif Tissue Int* 2006;78(2):65-71.
261. Van Langendonck L, Lefevre J, Claessens AL, Thomis M, Philippaerts R, Delvaux K, Lysens R, Renson R, Vanreusel B, Vanden Eynde B, Dequeker J, and Beunen G. Influence of participation in high-impact sports during adolescence and adulthood on bone mineral density in middle-aged men: a 27-year follow-up study. *Am J Epidemiol* 2003;158(6):525-533.
262. van Staa TP, Dennison EM, Leufkens HG, and Cooper C. Epidemiology of fractures in England and Wales. *Bone* 2001;29(6):517-522.
263. Vernikos J, and Schneider VS. Space, Gravity and the Physiology of Aging: Parallel or Convergent Disciplines? A Mini-Review. *Gerontology* 2010;56(2):157-166.
264. Vestergaard P, Mosekilde L, and Langdahl B. Fracture prevention in postmenopausal women. *Clinical evidence* 2011;2011.
265. Vestergaard P, Rejnmark L, and Mosekilde L. Increased mortality in patients with a hip fracture-effect of pre-morbid conditions and post-fracture complications. *Osteoporos Int* 2007;18(12):1583-1593.
266. Wallace BA, and Cumming RG. Systematic review of randomized trials of the effect of exercise on bone mass in pre- and postmenopausal women. *Calcif Tissue Int* 2000;67(1):10-18.
267. Warden SJ, Fuchs RK, Castillo AB, Nelson IR, and Turner CH. Exercise when young provides lifelong benefits to bone structure and strength. *J Bone Miner Res* 2007;22(2):251-259.
268. Wasnich RD. Epidemiology of osteoporosis in the United States of America. *Osteoporos Int* 1997;7 Suppl 3:S68-72.

269. Wehren LE, and Magaziner J. Hip fracture: risk factors and outcomes. *Curr Osteoporos Rep* 2003;1(2):78-85.

270. Welk GJ. *Physical activity assessments for health-related research*. Champaign, Ill.: Human Kinetics; 2002.

271. WHO Scientific Group on the Prevention and Management of Osteoporosis. *Prevention and management of osteoporosis : report of a WHO Scientific Group*. Geneva: World Health Organization; 2003.

272. Wickham CA, Walsh K, Cooper C, Barker DJ, Margetts BM, Morris J, and Bruce SA. Dietary calcium, physical activity, and risk of hip fracture: a prospective study. *BMJ* 1989;299(6704):889-892.

273. Wilsgaard T, Brenn T, and Arnesen E. Tracking of blood pressure in adult men: the Tromsø Study 1974-1986. *Journal of Epidemiology and Biostatistics* 1998;3(3):269-276.

274. Wilsgaard T, Emaus N, Ahmed LA, Grimnes G, Joakimsen RM, Omsland TK, and Berntsen GR. Lifestyle impact on lifetime bone loss in women and men: the Tromsø Study. *Am J Epidemiol* 2009;169(7):877-886.

275. Wilsgaard T, Jacobsen BK, Schirmer H, Thune I, Løchen ML, Njølstad I, and Arnesen E. Tracking of cardiovascular risk factors: the Tromsø study, 1979-1995. *Am J Epidemiol* 2001;154(5):418-426.

276. Wolff I, van Croonenborg JJ, Kemper HC, Kostense PJ, and Twisk JW. The effect of exercise training programs on bone mass: a meta-analysis of published controlled trials in pre- and postmenopausal women. *Osteoporos Int* 1999;9(1):1-12.

277. World Health Organization. Assessment of fracture risk and its application to screening for postmenopausal osteoporosis. Report of a WHO Study Group. *Tech Rep Ser* 1994;843:1-129.

278. World Health Organization. Our ageing world. http://www.who.int/ageing. World Health Organization; 2011.

279. You L, Temiyasathit S, Lee P, Kim CH, Tummala P, Yao W, Kingery W, Malone AM, Kwon RY, and Jacobs CR. Osteocytes as mechanosensors in the inhibition of bone resorption due to mechanical loading. *Bone* 2008;42(1):172-179.

280. Yung PS, Lai YM, Tung PY, Tsui HT, Wong CK, Hung VW, and Qin L. Effects of weight bearing and non-weight bearing exercises on bone properties using calcaneal quantitative ultrasound. *Br J Sports Med* 2005;39(8):547-551.

281. Zernicke R, MacKay C, and Lorincz C. Mechanisms of bone remodeling during weight-bearing exercise. *Appl Physiol Nutr Metab* 2006;31(6):655-660.

282. Zerwekh JE, Ruml LA, Gottschalk F, and Pak CY. The effects of twelve weeks of bed rest on bone histology, biochemical markers of bone turnover, and calcium homeostasis in eleven normal subjects. *J Bone Miner Res* 1998;13(10):1594-1601.

283. Aadahl M, Kjær M, and Jørgensen T. Associations between overall physical activity level and cardiovascular risk factors in an adult population. *Eur J Epidemiol* 2007;22(6):369-378.

Paper I

Paper II

Paper III

Appendix A

Questionnaire 1, the 2nd Tromsø Study 1979-80

Norwegian version

English version, preliminary translation
(the final version will be made available
at www.tromsostudy.com)

A

Har De, eller har De hatt:

		JA	NEI
Hjerteinfarkt?	33		
Angina pectoris (hjertekrampe)?	34		
Annen hjertesykdom?	35		
Åreforkalkning i bena?	36		
Hjerneslag?	37		
Sukkersyke?	38		

Er De under behandling for:

Høyt blodtrykk?	39		

Bruker De:

Nitroglycerin?	40		

B

Får De smerter eller ubehag i brystet når De:

		JA	NEI
Går i bakker, trapper eller fort på flat mark?	41		
Går i vanlig takt på flat mark?	42		

Hvis De får smerter eller ubehag i brystet ved gange, pleier De da å:

1 Stanse?	43		
2 Saktne farten?			
3 Fortsette i samme takt?			

Hvis De stanser eller saktner farten, forsvinner smertene da:

1 Etter mindre enn 10 minutter?	44		
2 Etter mer enn 10 minutter?			

Får De smerter i tykkleggen når De:

Går?	45		
Er i ro?	46		

Hvis De får leggsmerter, besvar da:

Forverres smertene ved raskere tempo eller i bakker?	47		
Gir smertene seg når De stopper?	48		

Har De vanligvis:

Hoste om morgenen?	49		
Oppspytt fra brystet om morgenen?	50		

C

	JA
Bevegelse og kroppslig anstrengelse i Deres **fritid**. Hvis aktiviteten varierer meget f.eks. mellom sommer og vinter så ta et gjennomsnitt.	
Spørsmålet gjelder bare det siste året.	
Sett kryss i den ruten hvor „JA" passer best.	
1 Leser, ser på fjernsyn eller annen stillesittende beskjeftigelse? 51	
2 Spaserer, sykler eller beveger Dem på annen måte minst 4 timer i uken? (Heri medregnes også gang eller sykling til arbeidestedet, søndagsturer m.m.)	
3 Driver mosjonsidrett, tyngre hagearbeid e.l.? (Merk at yirksomheten skal vare minst 4 timer i uken.	
4 Trener hardt eller driver konkurranseidrett, regelmessig og flere ganger i uken?	

D

		JA	NEI
Røyker De daglig for tiden?	52		
Hvis svaret var „JA" på forrige spørsmål, besvar da:			
Røyker De sigaretter daglig? (håndrullede eller fabrikkframstilte)	53		
Hvis De ikke røyker sigaretter nå, besvar da:			
Har De røykt sigaretter daglig tidligere?	54		
Hvis De svarte „JA", hvor lenge er det siden De sluttet?			
1 Mindre enn 3 måneder?	55		
2 3 måneder - 1 år?			
3 1 - 5 år?			
4 Mer enn 5 år?			

Besvares av dem som røyker nå eller har røykt tidligere:

Hvor mange år tilsammen har De røykt daglig?	56-57	Antall år:
Hvor mange sigaretter røyker eller røykte De daglig? Oppgi antall pr. dag (håndrullede + fabrikkframstilte)	58-61	Ant. sigaretter

Røyker De noe annet enn sigaretter daglig?

Sigarer eller serutter/cigarillos?	62		
Pipe?	63		

Hvis De røyker pipe, hvor mange pakker tobakk (50 gram) bruker De i pipa pr. uke?

Oppgi gjennomsnittlig antall pakker pr. uke.	64-66	Ant. tobakkpk

E

		JA	NEI
Har De vanligvis skiftarbeid eller nattarbeid?	67		
Kan De vanligvis komme hjem fra arbeidet:			
Hver dag?	68		
Hver helg?	69		
Har De i perioder lengre arbeidsdager enn vanlig? (f.eks. under sesongfiske, onnearbeid)	70		
Har De i løpet av siste året hatt:			
Sett kryss i den ruten hvor „JA" passer best.			
1 Overveiende stillesittende arbeid? (f.eks. skrivebordsarb., urmakerarb., montering)	71		
2 Arbeid som krever at De går mye? (f.eks. ekspeditørarb., lett industriarb., undervisn.)			
3 Arbeid hvor De går og løfter mye? (f.eks. postbud, tyngre industriarb., bygningsarb.)			
4 Tungt kroppsarbeid? (f.eks. skogsarbeid, tungt jordbruksarb., tungt bygningsarb.)			
Har De i løpet av de siste 12 mnd måttet flytte fra hjemstedet på grunn av forandring i arbeidssituasjonen?	72		
Er husmorarbeid Deres hovedyrke?	73		
Har De i løpet av de siste 12 mnd fått arbeidsledighetstrygd?	74		
Er De for tiden sykmeldt, eller får De attføringspenger?	75		
Har De full eller delvis uførepensjon?	76		

F

		JA	NEI	VET IKKE
Har en eller flere av foreldre eller søsken hatt hjerteinfarkt (sår på hjertet) eller angina pectoris (hjertekrampe)?	77			
Er to eller flere av Deres besteforeldre av finsk ætt?	78			
Er to eller flere av Deres besteforeldre av samisk ætt?	79			

A

Yes | No

Do you have, or have you had:

- A heart attack? 33
- Angina pectoris (heart cramp)? 34
- Any other heart disease? 35
- Hardened arteries in the legs? 36
- A cerebral stroke? 37
- Diabetes? 38

Are you being treated for:

- High blood pressure? 39

Do you use:

- Nitroglycerine? 40

B

Yes | No

Do you have get or discomfort in the chest when:

- Walking up hills or stairs, or walking fast on level ground? 41
- Walking at normal pace at level ground? . . . 42

If you get pain or discomfort in the chest when walking, do you usually:

1. Stop? 43
2. Slow down? .....
3. Carry on at the same pace? .....

If you stop or slow down, does the pain disappear:

1. Within 10 minutes? 44
2. After more than 10 minutes? .....

Do you get pain in the calf while:

- Walking? 45
- Resting? 46

If you get pain in the calf, then:

- Does the pain increase when you walk faster or uphill? 47
- Does the pain disappear when you stop? 48

Do you usually have:

- Cough in the morning? 49
- Phlegm chest in the morning? 50

C

Yes

Exercise and physical exertion in leisure time.
If your activity varies much, for example between summer and winter, then give an average.
The question refers only to the last twelve months:

Tick "Yes" beside the description that fits best:

1. Reading, watching TV, or other sedentary Activity? 51
2. Walking, cycling, or other forms of exercise at least 4 hours a week? .....
   (include walking or cycling to place of work, Sunday walk/stroll, etc.)
3. Participation in recreational sports, heavy gardening, etc.? .....
   (note: duration of activity at least 4 hours a week)
4. Participation in hard training or sports competitions, regularly several times a week?

D

Yes | No

- Do you smoke daily at present? 52

If the answer was "Yes" in the previous question, then:

- Do you smoke cigarettes daily? 53
  (hand-rolled or factory made)

If you do not smoke cigarettes at present, then:

- Have you previously smoked cigarettes daily? 54

If "Yes", how long is it since you stopped:

1. Less than 3 months? 55
2. 3 months to 1 year? .....
3. 1 to 5 years? .....
4. More than 5 years? .....

For those who smoke or have smoked previously:

- How many years altogether have you smoked daily? ..... 56-57 — No. of years
- How many cigarettes do you smoke, or did you, smoke daily? Give number of cigarettes per day 58
  (hand-rolled or factory made) — No. of cigarettes

Do you smoke tobacco products other than cigarettes daily?

- Cigars or cigarillos? 62
- A pipe? 63

If you smoke a pipe, how many packs of tobacco (50 grams) do you smoke per week?

- Give the average number of packs per week. 64 — No. of tobacco packs

E

Yes | No

- Do you usually work shifts or at nights? 67

Can you usually come home from work:

- Every day? 68
- Every weekend? 69
- Are there periods during which your working days are longer than usual? 70
  (e.g. fishing season, harvest)

During the last year, have you had:

Tick "Yes" beside description that fits best

1. Mostly sedentary work? 71
   (e.g. office work, watchmaker, light manual work)
2. Work that requires a lot of walking .....
   (e.g. shop assistant, light industrial work, teaching)
3. Work that requires a lot of walking and lifting?
   (e.g. postman, heavy industrial work, construction)
4. Heavy manual labour? .....
   (e.g. forestry, heavy farm-work, heavy construction)

- During the last 12 months, have you had to move for work reasons? 72
- Is housekeeping your main occupation? 73
- Have you within the last 12 months received unemployment benefit? 74
- Are you at present on sick leave, or receiving rehabilitation allowance? 75
- Do you receive a complete or partial disability pension?

F

Yes | No | Don't know

- Have one or more of your parents or sisters or brothers had a heart attack (heart wound) or angina pectoris (heart cramp)? 77
- Are two or more of your grandparents of Finnish origin? 78
- Are two or more of your grandparents of Sami origin? 79

Appendix B

Questionnaire 1, the 3rd Tromsø Study 1986-87

Norwegian version

English version, preliminary translation
(the final version will be made available
at www.tromsostudy.com)

HELSEUNDERSØKELSEN I TROMSØ

TROMSØ III

(Gjelder bare den person som brevet er adressert til.)

Helseundersøkelsen kommer nå til Deres distrikt.

Tid og sted for frammøte vil De finne nedenfor.

De finner en orientering om undersøkelsen i den vedlagte brosjyren.

Vi ber Dem vennligst fylle ut spørreskjemaet på baksiden og ta med dette til undersøkelsen.

Vi ber Dem eventuelt melde fra om fravær på den vedlagte fraværsmeldingen.

Kvinner 1930-66
Menn 1925-66

Med hilsen

KOMMUNEHELSETJENESTEN I TROMSØ
FYLKESLEGEN I TROMS UNIVERSITETET I TROMSØ
STATENS HELSEUNDERSØKELSER

Født dato | Personnr. | Kommune | Kretsnr.

Møtested | Kjønn | Første bokstav i etternavn | Dag og dato | Klokkeslett

HØYDE	VEKT	ANM 70	M	P	Ø	KODE 75	AVVIK	ARM	MAN	APP.NR.	TSM 82

MÅLING 1				MÅLING 2				MÅLING 3			
MAR		S		MAR		S		MAR		S	
	85		88		91		94		97		100
HR		D		HR		D		HR		D	
	103		106		109		112		115		118

A FAMILIE

Har en eller flere av foreldre eller søsken hatt hjerteinfarkt (sår på hjertet) eller angina pectoris (hjertekrampe)? 12

JA	NEI	VET IKKE

B EGEN SYKDOM

Har De, eller har De hatt:

	JA	NEI
Hjerteinfarkt? 13		
Angina pectoris (hjertekrampe)? 14		
Hjerneslag? 15		
Sukkersyke? 16		

Er De under behandling for:

Høyt blodtrykk? 17		

Bruker De:

Nitroglycerin? 18		

C SYMPTOMER

Får De smerter eller ubehag i brystet når De:

	JA	NEI
Går i bakker, trapper eller fort på flat mark? 19		
Går i vanlig takt på flat mark? 20		

Dersom De får smerter eller vondt i brystet ved gange, pleier De da:

Stoppe? 21	1
Saktne farten?	2
Fortsette i samme takt?	3

Dersom De stopper eller saktner farten, går da smertene bort:

Etter mindre enn 10 minutter? 22	1
Etter mer enn 10 minutter?	2

Har De vanligvis:

	JA	NEI
Hoste om morgenen? 23		
Oppspytt fra brystet om morgenen? 24		

D MOSJON

Bevegelse og kroppslig aktivitet i Deres fritid. Dersom aktiviteten varierer mye, f.eks. mellom sommer og vinter, så ta ett gjennomsnitt. Spørsmålet gjelder bare det siste året.

Sett kryss i den ruten som passer best.

Leser, ser på fjernsyn eller annen stillesittende beskjeftigelse? 25	1
Spaserer, sykler eller beveger Dem på annen måte minst 4 timer i uken? ..... (Her skal De også regne med gang eller sykling til arbeidsstedet, søndagsturer m.m.)	2
Driver mosjonsidrett, tyngre hagearbeid e.l.? .. (Merk at aktiviteten skal vare i minst 4 timer i uken.)	3
Trener hardt eller driver konkurranseidrett regelmessig og flere ganger i uken?	4

E SALT/FETT

Hvor ofte bruker De salt kjøtt eller salt fisk til middag?

Sett kryss i den ruten som passer best.

Aldri eller sjeldnere enn en gang i måneden 26	1
Inntil en gang i uken	2
Inntil to ganger i uken	3
Mer enn to ganger i uken	4

Hvor ofte pleier De å strø ekstra salt på middagsmaten?

Sett kryss i den ruten som passer best.

Sjelden eller aldri 27	1
Av og til eller ofte	2
Alltid eller nesten alltid	3

Hva slags margarin eller smør bruker De vanligvis på brødet?

Sett kryss i den ruten som passer best.

Bruker ikke smør eller margarin på brød 28	1
Smør	2
Hard margarin	3
Myk (Soft) margarin	4
Smør/margarin blanding	5

Hva slags fett blir vanligvis brukt til matlaging i husholdningen Deres?

Sett kryss i den ruten som passer best.

Smør eller hard margarin 29	1
Myk (Soft) margarin eller olje	2
Smør/margarin blanding	3

F RØYKING

	JA	NEI
Røyker De daglig for tida? 30		

Dersom svaret er «JA», svar da på dette:

Røyker De sigaretter daglig? ..... 31 (håndrullede eller fabrikkfremstilte)	

Dersom De ikke røyker sigaretter nå, svar da på dette:

Har De røykt sigaretter daglig tidligere? 32	

Dersom De svarte «JA», hvor lenge er det da siden De sluttet?

Mindre enn 3 måneder? 33	1
3 måneder – 1 år?	2
1–5 år?	3
Mer enn 5 år?	4

Skal besvares av de som røyker nå eller som har røykt tidligere:

Hvor mange år til sammen har De røykt daglig? 34	År
Hvor mange sigaretter røyker eller røykte De daglig? Gi opp antallet sigaretter daglig ..... 36 (håndrullede + fabrikkframstilte)	Sigaretter

Røyker De noe annet enn sigaretter daglig?

Sigarer eller serutter/sigarillos? 40	
Pipe? 41	

Dersom De røyker pipe, hvor mange pakker tobakk (50 gram) bruker De i pipen på en uke?

Gi opp gjennomsnittlig tall på pakker i uken 42	Tobakkspk.

G KAFFE

Hvor mange kopper kaffe drikker De vanligvis hver dag?

Sett kryss i den ruten som passer best.

Drikker ikke kaffe, eller mindre enn en kopp 45	1
1 – 4 kopper	2
5 – 8 kopper	3
9 eller flere kopper	4

Hva slags kaffe drikker De vanligvis hver dag?

Kokekaffe 46	
Filterkaffe 47	
Pulverkaffe 48	
Koffeinfri kaffe 49	
Drikker ikke kaffe 50	

H ARBEID

	JA	NEI
Har De i de siste 12 månedene fått arbeidsledighetstrygd? 51		
Er De for tiden sykemeldt, eller får De attføringspenger? 52		
Har De full eller delvis uførepensjon? 53		
Har De vanligvis skiftarbeid eller nattarbeid 54		

Har De i det siste året hatt:

Sett kryss i den ruten som passer best.

For det meste stillesittende arbeid? ..... 55 (f.eks. skrivebordsarb., urmakerarb., montering)	1
Arbeide som krever at De går mye? ..... (f.eks. ekspeditørarb., lett industriarb., undervisn.)	2
Arbeide der De går og løfter mye? ..... (f.eks. postbud, tyngre industriarb., bygningsarb.)	3
Tungt kroppsarbeid? ..... (f.eks. skogsarb., tungt jordbruksarb., tungt bygningarb.)	4

	JA	NEI
Er husmorarbeid hovedyrket Deres? 56		

I ETTERUNDERSØKELSE

	JA	NEI
Har noen i husstanden Deres (utenom Dem selv) vært innkalt til nærmere undersøkelse hos lege etter den siste hjertekarundersøkelsen? 57		

Dersom denne helseundersøkelsen viser at De bør undersøkes nærmere: Hvilken almenpraktiserende lege ønsker De da å bli henvist til?

Skriv navnet på legen her ↓

..... 58

Ingen spesiell lege .....

61

Ikke skriv her

THE TROMSØ HEALTH SURVEY

(Applies only to the person to whom the letter is addressed.)

The health survey is coming now to your district.

You find the time and place for attendance below.

You will find an orientation on the survey in the enclosed brochure.

We would like you to fill in the form on the back and take it with you to the survey.

We ask those possibly not attending to report their absence in the attached absence report.

Yours sincerely

MUNICIPAL HEALTH AUTHORITY OF TROMSØ
COUNTY DOCTOR OF TROMS UNIVERSITY OF TROMSØ
NATIONAL HEALTH SCREENING SERVICE

Birth date | Personal number | Municipality | Circuit number

Meeting place | Gender | First letter of last name | Day and date | Time

HEIGHT ⌊⌊⌊ WEIGHT ⌊⌊⌊⌊ ANM 70 ⌊	M ⌊ P ⌊ Ø ⌊ KODE 75 ⌊⌊	AVVIK ⌊ ARM ⌊⌊ MAN ⌊ APP.NR. ⌊⌊⌊ TSM 82 ⌊
MEASUREMENT 1	**MEASUREMENT 2**	**MEASUREMENT 3**
MAR ⌊⌊⌊ 85 S ⌊⌊⌊ 88	MAR ⌊⌊⌊ 91 S ⌊⌊⌊ 94	MAR ⌊⌊⌊ 97 S ⌊⌊⌊ 100
HR ⌊⌊⌊ 103 D ⌊⌊⌊ 106	HR ⌊⌊⌊ 109 D ⌊⌊⌊ 112	HR ⌊⌊⌊ 115 D ⌊⌊⌊ 118

A FAMILY

Have one or more of your parents or siblings had a heart attack (heart wound) or angina pectoris (heart cramp)? 12

B OWN ILLNESSES

Do you have, or have you had:

A heart attack? 13
Angina pectoris (heart cramp)? 14
A cerebral stroke? 15
Diabetes? 16

Are you been treated for:

High blood pressure? 17

Do you use:

Nitroglycerine? 18

C SYMPTOMS

Do you get pain or discomfort in the chest when:

Walking up hills or stairs, or walking fast on level ground? 19
Walking at normal pace at level ground? 20

If you get pain or discomfort in the chest when walking, do you usually:

Stop? 21
Slow down? .....
Carry on at the same pace? .....

If you stop or slow down, does the pain disappear:

After less than 10 minutes? 22
After more than 10 minutes? .....

Do you usually have:

Cough in the morning? 23
Phlegm chest in the morning? 24

D EXERCISE

Exercise and physical exertion in leisure time. If your activity varies much, for example between summer and winter, then give an average. The question refers only to the last year:

Tick the most appropriate box.

Reading, watching TV, or other sedentary activity? 25

Walking, cycling or other forms of exercise at least 4 hours a week? .....
(include walking or cycling to place of work, Sunday walk/stroll, etc.)

Participation in recreational sports, heavy gardening, etc.? .....
(note: duration of activity at least 4 hours a week)

Participation in hard training or sports competitions, regularly several times a week? ...

E SALT/ FAT

How often do you use salted meat or salted fish for dinner?

Tick the most appropriate box.

Never or less than once a month 26
Once a week or less .....
Twice a week or less .....
More than twice a week.....

How often do you add extra salt to your dinner?

Tick the most appropriate box.

Rarely or never 27
Sometimes or often .....
Always or nearly always .....

What type of margarine or butter do you usually use on your bread?

Tick the most appropriate box.

Do not use margarine or butter on bread 28
Butter .....
Hard Margarine .....
Soft (soya) margarine spread.....
Butter/ margarine mixtures .....

What type of cooking fat do you normally use in your household?

Tick the most appropriate box.

Butter or hard margarine 29
Soft (soya) margarine or oil .....
Butter/ margarine mixtures .....

F SMOKING

Do you smoke daily at present? 30

If the answer is "YES", then:

Do you smoke cigarettes daily? 31
(hand-rolled or factory made)

If you do not smoke cigarettes at present, then:

Have you previously smoked cigarettes daily? ... 32

If you answered "Yes", how long is it since you stopped:

Less than 3 months? 33
3 months to 1 year? .....
1 -5 years? .....
More than 5 years? .....

To be answered by those who smoke or who have smoked previously:

How many years altogether have you smoked daily? 34

How many cigarettes do you smoke or did you smoke daily? .....
Give number of cigarettes per day 36
(hand-rolled + factory made)

Do you smoke anything else other than cigarettes daily?

Cigars or cigarillos/cheroots? 40
A pipe? 41

If you smoke a pipe, how many packs of tobacco (50 grams) do you smoke per week?

Give the average number of packs per week 42

G COFFEE

How many cups of coffee do you usually drink daily?

Tick the most appropriate box.

Do not drink coffee, or less than one cup 45
1 -4 cups .....
5 -8 cups .....
9 or more cups .....

What type of coffee do you usually drink daily?

Coarsely ground coffee for brewing (boiled) 46
Finely ground filter coffee 47
Instant coffee 48
Caffeine free coffee 49
Do not drink coffee 50

H EMPLOYMENT

Have you within the last 12 months received unemployment benefits? 51

Are you at present on sick lease, or receiving rehabilitation allowance? 52

Do you receive a complete or partial disability pension? 53

Do you usually work shifts or at night? 54

During the last year, have you had:

Tick the most appropriate box.

Mostly sedentary work? 55
(e.g. office work, watchmaker, light manual work)
Work that requires a lot of walking? .....
(e.g. shop assistant, light industrial work, teaching)
Work that requires a lot of walking and lifting? ...
(e.g. postman, heavy industrial work, construction)
Heavy manual labour? .....
(e.g. forestry, heavy farm-work, heavy construction)

Is house-keeping your main occupation? ... 56

I FOLLOW-UP EXAMINATION

Has any one in your household (other than yourself) been called in to a doctor for further medical examination after the previous cardiovascular disease survey? 57

If this survey suggests that you need a further medical examination, which general practitioner do you wish to be referred to?

Write the doctor's name here? →

..... 58

No particular doctor 61

Don't write here

Appendix C

Questionnaire 1, the 4th Tromsø Study 1994-95

Norwegian version

English version, preliminary translation
(the final version will be made available
at www.tromsostudy.com)

Innbydelse til

HELSEUNDERSØKELSEN

Fødselsdato	Personnr.	Kommune	Kretsnr.

Velkommen til helseundersøkelsen i Tromsø!

Helseundersøkelsen kommer nå til Tromsø. Tid og sted for frammøte finner du nedenfor. Du finner også en orientering om undersøkelsen i den vedlagte brosjyren.

Vi ber deg fylle ut spørreskjemaet på baksiden og ta det med til undersøkelsen.

Undersøkelsen blir mest verdifull om frammøtet blir så fullstendig som mulig. Vi håper derfor at du har mulighet til å komme. Møt selv om du kjenner deg frisk, om du er under legebehandling, eller om du har fått målt kolesterol og blodtrykk i den senere tid.

Vennlig hilsen
Kommunehelsetjenesten
Fagområdet medisin, Universitetet i Tromsø
Statens helseundersøkelser

EGEN HELSE

Hvordan er helsen din nå? *Sett bare ett kryss.*

Dårlig	12	1
Ikke helt god		2
God		3
Svært god		4

Har du, eller har du hatt:

	JA	NEI	Alder første gang
Hjerteinfarkt 13			år
Angina pectoris (hjertekrampe) 16			år
Hjerneslag/hjerneblødning 19			år
Astma 22			år
Diabetes (sukkersyke) 25			år

Bruker du medisin mot høyt blodtrykk?

Nå	28	1
Før, men ikke nå		2
Aldri brukt		3

Har du i løpet av det siste året vært plaget med smerter og/eller stivhet i muskler og ledd som har vart i minst 3 måneder sammenhengende? 29 — JA / NEI

Har du de siste to ukene følt deg:

	Nei	Litt	En god del	Svært mye
Nervøs og urolig? 30				
Plaget av angst? 31				
Trygg og rolig? 32				
Irritabel? 33				
Glad og optimistisk? 34				
Nedfor/deprimert? 35				
Ensom? 36				
	1	2	3	4

RØYKING

Røykte noen av de voksne hjemme da du vokste opp? 37 — JA / NEI

Bor du, eller har du bodd, sammen med noen dagligrøykere etter at du fylte 20 år? 38 — JA / NEI

Hvis "JA", hvor mange år tilsammen? 39 — Antall år

Hvor lenge er du vanligvis daglig tilstede i røykfylt rom? 41 — Antall timer

Sett 0 hvis du ikke oppholder deg i røykfylt rom.

Røyker du selv:

	JA	NEI
Sigaretter daglig? 43		
Sigarer/sigarillos daglig? 44		
Pipe daglig? 45		

Hvis du har røykt daglig tidligere, hvor lenge er det siden du sluttet? 46 — Antall år

Hvis du røyker daglig nå eller har røykt tidligere:

Hvor mange sigaretter røyker eller røykte du vanligvis daglig? 48 — Antall sigaretter

Hvor gammel var du da du begynte å røyke daglig? 52 — Alder år

Hvor mange år tilsammen har du røykt daglig? 54 — Antall år

MOSJON

Hvordan har din fysiske aktivitet i fritiden vært det siste året? *Tenk deg et ukentlig gjennomsnitt for året.*
Arbeidsvei regnes som fritid.

	Timer pr. uke: Ingen	Under 1	1-2	3 og mer
Lett aktivitet *(ikke svett/andpusten)* 56				
Hard fysisk aktivitet *(svett/andpusten)* 57				
	1	2	3	4

KAFFE

Hvor mange kopper kaffe drikker du daglig?
Sett 0 hvis du ikke drikker kaffe daglig.

Kokekaffe	58	Antall kopper
Annen kaffe	60	Antall kopper

ALKOHOL

Er du total avholdsmann/-kvinne? 62 — JA / NEI

Hvor mange ganger i måneden drikker du vanligvis alkohol? *Regn ikke med lettøl.*
Sett 0 hvis mindre enn 1 gang i mnd. 63 — Antall ganger

Hvor mange glass øl, vin eller brennevin drikker du vanligvis i løpet av to uker? 65
Regn ikke med lettøl.
Sett 0 hvis du ikke drikker alkohol.

Øl	Vin	Brennevin
glass	glass	glass

FETT

Hva slags margarin eller smør bruker du vanligvis på brødet? *Sett ett kryss.*

Bruker ikke smør/margarin	71	1
Meierismør		2
Hard margarin		3
Bløt (soft) margarin		4
Smør/margarin blanding		5
Lettmargarin		6

UTDANNING/ARBEID

Hvilken utdanning er den høyeste du har fullført?

Grunnskole, 7-10 år, framhaldsskole, folkehøgskole	72	1
Realskole, middelskole, yrkesskole, 1-2-årig videregående skole		2
Artium, øk.gymnas, allmennfaglig retning i videregående skole		3
Høgskole/universitet, mindre enn 4 år		4
Høgskole/universitet, 4 år eller mer		5

Hva slags arbeidssituasjon har du nå?

Lønnet arbeid	73	
Heltids husarbeid	74	
Utdanning, militærtjeneste	75	
Arbeidsledig, permittert	76	

Hvor mange timer lønnet arbeid har du i uka? 77 — Antall timer

Mottar du nå noen av følgende ytelser?

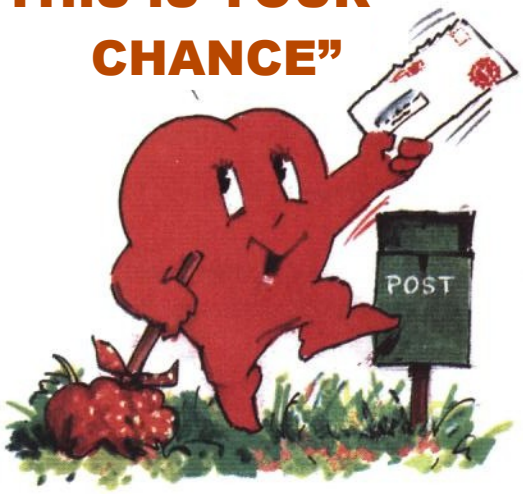
Syketrygd (sykmeldt)	79	
Attføring	80	
Uførepensjon	81	
Alderspensjon	82	
Sosialstøtte	83	
Arbeidsløshetstrygd	84	

SYKDOM I FAMILIEN

Har en eller flere av foreldre eller søsken hatt hjerteinfarkt (sår på hjertet) eller angina pectoris (hjertekrampe)? 85 — JA / NEI / VET IKKE

HEALTH SURVEY
Invitation

"THIS IS YOUR CHANCE"



Date of birth **Social security No.** **Municipality** **Electoral ward No.**

Welcome to the Tromsø Health Survey!

The Health Survey is coming to Tromsø. This leaflet will tell you when and where. You will also find information about the survey in the enclosed brochure.

We would like you to fill in the form overleaf and take it with you to the examination.

The more people take part in the survey, the more valuable its results will be. We hope, therefore, that you will be able to come. Attend even if you feel healthy, if you are currently receiving medical treatment, or if you have had your cholesterol and blood pressure measured recently.

Yours sincerely,
Municipal Health Authorities
Faculty of Medicine - University of Tromsø
National Health Screening Service

"THIS IS A REAL OPPORTUNITY- TAKE IT!"

YOUR OWN HEALTH

What is your current state of health? *Tick one box only.*

Poor	12	1
Not so good		2
Good		3
Very good		4

Do you have, or have you had:

		Yes	No	Age first time
A heart attack	13			years
Angina pectoris (heart cramp)	16			years
A cerebral stroke/ brain haemorrhage	19			years
Asthma	22			years
Diabetes	25			years

Do you take medications for high blood pressure?

Currently	28	1
Previously, but not now		2
Never used		3

Have you during the last year suffered from pains and/or stiffness in muscles and joints that have lasted continuously for at least 3 months? 29 Yes / No

Have you in the last two weeks felt:

		No	A little	A lot	Very much
Nervous or worried?	30				
Anxious?	31				
Confident and calm?	32				
Irritable?	33				
Happy and optimistic?	34				
Down/depressed?	35				
Lonely?	36				
		1	2	3	4

SMOKING

Did any of the adults at home smoke while you were growing up? 37 Yes / No

Do you currently, or did you previously, live together with daily smokers after your 20th birthday? 38 Yes / No

If "YES", for how many years in all? 39 ____ Years

How many hours a day do you normally spend in smoke-filled rooms? 41 ____ Hours

Put 0 if you do not spend time in smoke-filled rooms.

Do you yourself smoke:

		Yes	No
Cigarettes daily?	43		
Cigars/ cigarillos daily?	44		
A pipe daily?	45		

If you previously smoked daily, how long is it since you stopped? 46 ____ Years

If you currently smoke, or have smoked before:

How many cigarettes do you or did you usually smoke per day? 48 ____ cigarettes

How old were you when you began smoking daily? 52 ____ Age years

How many years in all have you smoked daily? 54 ____ Years

EXERCISE

How has your physical activity in leisure time been during this last year? *Think of your weekly average for the year.*

Time spent going to work counts as leisure time.

		Hours per week: None	Less than 1	1-2	3 or more
Light activity *(not sweating/out of breath)*	56				
Hard activity *(sweating/ out of breath)*	57				
		1	2	3	4

COFFEE

How many cups of coffee do you drink daily?

Put 0 if you do not drink coffee daily.

Coarsely ground coffee for brewing	58	Cups
Other coffee	60	Cups

ALCOHOL

Are you a teetotaller? 62 Yes / No

How many times a month do you normally drink alcohol? *Do not count low-alcohol beer.*

Put 0 if less than once a month. 63 ____ Times

How many glasses of beer, wine or spirits do you normally drink in a fortnight? 65

Do not count low-alcohol beer.

Put 0 if less than once a month.

Beer	Wine	Spirits
Glasses	Glasses	Glasses

FAT

What type of margarine or butter do you usually use on bread? *Tick one box only.*

Don't use butter/margarine	71	1
Butter		2
Hard margarine		3
Soft margarine		4
Butter/margarine mixtures		5
Light margarine		6

EDUCATION/WORK

What is the highest level of education you have completed?

7-10 years primary/secondary school, modern secondary school	72	1
Technical school, middle school, vocational school, 1-2 years senior high school		2
High school diploma (3-4 years)		3
College/university, less than 4 years		4
College/university, 4 or more years		5

What is your current work situation?

Paid work	73	
Full-time housework	74	
Education, military service..	75	
Unemployed, on leave without payment	76	

How many hours of paid work do you have per week? 77 ____ No. of hours

Do you receive any of the following benefits?

Sickness benefit (sick leave)	79	
Rehabilitation benefit	80	
Disability pension	81	
Old-age pension	82	
Social welfare benefit	83	
Unemployment benefit	84	

ILLNESS IN THE FAMILY

Have one or more of your parents or siblings had a heart attack or had angina (heart cramp)? 85

Yes	No	Don't know

Appendix D

Questionnaire 1 (<70 years), the 5th Tromsø Study 2001-02

Norwegian version

English version, preliminary translation
(the final version will be made available
at www.tromsostudy.com)

10. MOSJON OG FYSISK AKTIVITET

10.1 Hvordan har din fysiske aktivitet i fritiden vært det siste året?
Tenk deg et ukentlig gjennomsnitt for året.
Arbeidsvei regnes som fritid. Besvar begge spørsmålene.

	Timer pr. uke: Ingen	Under 1	1-2	3 og mer
Lett aktivitet *(Ikke svett/andpusten)*	☐	☐	☐	☐
Hard fysisk aktivitet *(Svett/andpusten)*	☐ 1	☐ 2	☐ 3	☐ 4

10.2 Angi bevegelse og kroppslig anstrengelse i din fritid. Hvis aktiviteten varierer meget f.eks. mellom sommer og vinter, så ta et gjennomsnitt. Spørsmålet gjelder bare det siste året.
(Sett kryss i den ruta som passer best)

Leser, ser på fjernsyn eller annen stillesittende beskjeftigelse? ☐ 1

Spaserer, sykler eller beveger deg på annen måte minst 4 timer i uka? ☐ 2
(Her skal du også regne med gang eller sykling til arbeidsstedet, søndagsturer m.m.)

Driver mosjonsidrett, tyngre hagearbeid e.l.? ☐ 3
(Merk at aktiviteten skal vare minst 4 timer i uka)

Trener hardt eller driver konkurranseidrett regelmessig og flere ganger i uka? ☐ 4

11. FAMILIE OG VENNER

11.1 Bor du sammen med:
Ektefelle/samboer? JA ☐ NEI ☐

11.2 Hvor mange gode venner har du? *Antall venner* ☐☐

Regn med de du kan snakke fortrolig med og som kan gi deg hjelp dersom du trenger det. Tell ikke med de du bor sammen med, men ta med andre slektninger.

11.3 Hvor stor interesse viser folk for det du gjør?
(Sett bare ett kryss)

Stor interesse	Noe interesse	Litt interesse	Ingen interesse	Usikkert
☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

11.4 Hvor mange foreninger, lag, grupper, kirkesamfunn e.l. deltar du i på fritiden? *Antall* ☐☐
(Skriv 0 hvis ingen)

11.5 Føler du at du kan påvirke det som skjer i lokalsamfunnet der du bor? *(Sett bare ett kryss)*

Ja, i stor grad	Ja, en del	Ja, i liten grad	Nei	Har ikke forsøkt
☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

12. SYKDOM I FAMILIEN

12.1 Har en eller flere av dine foreldre eller søsken hatt hjerteinfarkt (sår på hjertet) eller angina pectoris (hjertekrampe)?

JA	NEI	VET IKKE
☐	☐	☐

12.2 Kryss av for de slektningene som har eller har hatt noen av sykdommene: *(Sett kryss for hver linje)*

	Mor	Far	Bror	Søster	Barn	Ingen av disse
Hjerneslag eller hjerneblødning	☐	☐	☐	☐	☐	☐
Hjerteinfarkt før 60 års alder	☐	☐	☐	☐	☐	☐
Astma	☐	☐	☐	☐	☐	☐
Kreftsykdom	☐	☐	☐	☐	☐	☐
Diabetes (sukkersyke)	☐	☐	☐	☐	☐	☐

12.3 Hvis noen slektninger har diabetes, i hvilken alder fikk de diabetes (hvis for eks. flere søsken, før opp den som fikk det tidligst i livet):

Vet ikke, ikke aktuelt	Mors alder	Fars alder	Brors alder	Søsters alder	Barns alder
☐	☐☐	☐☐	☐☐	☐☐	☐☐

13. BRUK AV MEDISINER

Med medisiner mener vi her medisiner kjøpt på apotek.
Kosttilskudd og vitaminer regnes ikke med her.

13.1 Bruker du?

	Nå	Før, men ikke nå	Aldri brukt
Medisin mot høyt blodtrykk	☐	☐	☐
Kolesterolsenkende medisin	☐	☐	☐

13.2 Hvor ofte har du i løpet av de siste 4 ukene brukt følgende medisiner? *(Sett ett kryss pr. linje)*

	Ikke brukt siste 4 uker	Sjeldnere enn hver uke	Hver uke, men ikke daglig	Daglig
Smertestillende uten resept	☐	☐	☐	☐
Smertestillende på resept	☐	☐	☐	☐
Sovemedisin	☐	☐	☐	☐
Beroligende medisin	☐	☐	☐	☐
Medisin mot depresjon	☐	☐	☐	☐
Annen medisin på resept	☐ 1	☐ 2	☐ 3	☐ 4

13.3 For de medisinene som du har krysset av for i pkt. 13.1 og 13.2, og som du har brukt i løpet av de siste 4 ukene:

Angi navnet og hvilken grunn det er til at du tar/har tatt disse (sykdom eller symptom):
(Kryss av for hvor lenge du har brukt medisinen)

Navn på medisinen: *(ett navn pr. linje):*	Grunn til bruk av medisinen:	Hvor lenge har du brukt medisinen? Inntil 1 år	Ett år eller mer
		☐	☐
		☐	☐
		☐	☐
		☐	☐
		☐	☐
		☐	☐
		☐	☐

Dersom det ikke er nok plass her, kan du fortsette på eget ark som du legger ved.

14. RESTEN AV SKJEMAET SKAL BARE BESVARES AV KVINNER

14.1 Hvor gammel var du da du fikk menstruasjon aller første gang? *Alder i år* ☐☐

14.2 Hvis du ikke lenger får menstruasjon, hvor gammel var du da den sluttet? *Alder i år* ☐☐

14.3 Er du gravid nå?

Ja	Nei	Usikker	Over fruktbar alder
☐ 1	☐ 2	☐ 3	☐ 4

14.4 Hvor mange barn har du født? *Antall barn* ☐☐

14.5 Bruker du, eller har du brukt?
(Sett ett kryss for hver linje)

	Nå	Før, men ikke nå	Aldri
P-pille/minipille/p-sprøyte	☐	☐	☐
Hormonspiral *(ikke vanlig spiral)*	☐	☐	☐
Østrogen *(tabletter eller plaster)*	☐	☐	☐
Østrogen *(krem eller stikkpiller)*	☐	☐	☐

14.6 Hvis du bruker/har brukt reseptpliktig østrogen:
Hvor lenge har du brukt dette? *Antall år* ☐☐

14.7 Hvis du bruker p-pille, minipille, p-sprøyte, hormonspiral eller østrogen; hvilket merke bruker du?

IE 050000 - 1042-1 - 24.000 - Beyer Hecos 02.01

Helse-undersøkelsen

Personlig innbydelse

Ikke skriv her:

5.3 (Kommune) ☐☐☐ (Fylke) ☐☐ (Land) ☐☐☐

9.3 (Virksomhet) ☐☐☐☐☐☐ 9.4 (Yrke) ☐☐☐☐☐☐ 14.7 (Merke) ☐☐☐☐☐☐

1. EGEN HELSE

1.1 Hvordan er helsen din nå? *(Sett bare ett kryss)*

Dårlig ☐ 1 | Ikke helt god ☐ 2 | God ☐ 3 | Svært god ☐ 4

1.2 Har du, eller har du hatt?:

	JA	NEI	Alder første gang
Astma	☐	☐	
Høysnue	☐	☐	
Kronisk bronkitt/emfysem	☐	☐	
Diabetes (sukkersyke)	☐	☐	
Benskjørhet (osteoporose)	☐	☐	
Fibromyalgi/kronisk smertesyndrom	☐	☐	
Psykiske plager som du har søkt hjelp for	☐	☐	
Hjerteinfarkt	☐	☐	
Angina pectoris (hjertekrampe)	☐	☐	
Hjerneslag/hjerneblødning	☐	☐	

1.3 Har du merket anfall med plutselig endring i pulsen eller hjerterytmen siste året? JA ☐ NEI ☐

1.4 Får du smerter eller ubehag i brystet når du: JA NEI

Går i bakker, trapper eller fort på flat mark? ☐ ☐

1.5 Hvis du får slike smerter, pleier du da å:

Stoppe? ☐ 1 | Saktne farten? ☐ 2 | Fortsette i samme takt? ☐ 3

1.6 Dersom du stopper, forsvinner smertene da etter mindre enn 10 minutter? JA ☐ NEI ☐

1.7 Kan slike smerter opptre selv om du er i ro? JA ☐ NEI ☐

2. MUSKEL OG SKJELETTPLAGER

2.1 Har du vært plaget med smerter og/eller stivhet i muskler og ledd i løpet av de siste 4 ukene?
(Varighet angis bare hvis du har hatt plager)

	Ikke plaget	En del plaget	Sterkt plaget	Varighet: Inntil 2 uker	Varighet: 2 uker eller mer
Nakke/skuldre	☐	☐	☐	☐	☐
Armer, hender	☐	☐	☐	☐	☐
Øvre del av ryggen	☐	☐	☐	☐	☐
Korsryggen	☐	☐	☐	☐	☐
Hofter, ben, føtter	☐	☐	☐	☐	☐
Andre steder	☐	☐	☐	☐	☐
	1	2	3	1	2

2.2 Har du noen gang hatt: JA NEI Alder siste gang

Brudd i håndledd/underarm? ☐ ☐

Lårhalsbrudd? ☐ ☐

3. ANDRE PLAGER

3.1 Under finner du en liste over ulike problemer. Har du opplevd noe av dette den siste uken (til og med i dag)?
(Sett ett kryss for hver plage)

	Ikke plaget	Litt plaget	Ganske mye	Veldig mye
Plutselig frykt uten grunn	☐	☐	☐	☐
Føler deg redd eller engstelig	☐	☐	☐	☐
Matthet eller svimmelhet	☐	☐	☐	☐
Føler deg anspent eller oppjaget	☐	☐	☐	☐
Lett for å klandre deg selv	☐	☐	☐	☐
Søvnproblemer	☐	☐	☐	☐
Nedtrykt, tungsindig	☐	☐	☐	☐
Følelse av å være unyttig, lite verd	☐	☐	☐	☐
Følelse av at alt er et slit	☐	☐	☐	☐
Følelse av håpløshet mht. framtida	☐	☐	☐	☐
	1	2	3	4

4. BRUK AV HELSETJENESTER

4.1 Hvor mange ganger de siste 12 månedene har du selv brukt:
(Sett ett kryss for hver linje)

	Ingen	1-3 ganger	4 eller flere
Allmennpraktiserende lege	☐	☐	☐
Bedriftslege	☐	☐	☐
Psykolog eller psykiater *(privat eller på poliklinikk)*	☐	☐	☐
Annen spesialist *(privat eller på poliklinikk)*	☐	☐	☐
Legevakt *(privat eller offentlig)*	☐	☐	☐
Sykehusinnleggelse	☐	☐	☐
Hjemmesykepleie	☐	☐	☐
Fysioterapeut	☐	☐	☐
Kiropraktor	☐	☐	☐
Tannlege	☐	☐	☐
Alternativ behandler	☐	☐	☐

5. OPPVEKST OG TILHØRIGHET

5.1 Hvor lenge har du samlet bodd i fylket? ☐☐ år
(Sett 0 hvis mindre enn et halvt år)

5.2 Hvor lenge har du samlet bodd i kommunen? ☐☐ år
(Sett 0 hvis mindre enn et halvt år)

5.3 Hvor bodde du det meste av tiden før du fylte 16 år?
(kryss av for ett alternativ og spesifiser)

Samme kommune ☐ 1

Annen kommune i fylket ☐ 2 Hvilken: _____

Annet fylke i Norge ☐ 3 Hvilket: _____

Utenfor Norge ☐ 4 Land: _____

5.4 Har du flyttet i løpet av de siste fem årene?

Nei ☐ 1 | Ja, en gang ☐ 2 | Ja, flere ganger ☐ 3

6. VEKT

6.1 Anslå din vekt da du var 25 år gammel: ☐☐☐ **hele kg**

7. MAT OG DRIKKE

7.1 Hvor ofte spiser du vanligvis disse matvarene?
(Sett ett kryss pr. linje)

	Sjelden /aldri	1-3 g. pr.mnd	1-3 g. pr.uke	4-6 g. pr.uke	1-2 g. pr.dag	3 g. el. mer pr.dag
Frukt, bær	☐	☐	☐	☐	☐	☐
Ost *(alle typer)*	☐	☐	☐	☐	☐	☐
Poteter	☐	☐	☐	☐	☐	☐
Kokte grønnsaker	☐	☐	☐	☐	☐	☐
Rå grønnsaker/salat	☐	☐	☐	☐	☐	☐
Feit fisk *(f.eks. laks, ørret, makrell, sild)*	☐	☐	☐	☐	☐	☐
	1	2	3	4	5	6

7.2 Hva slags fett bruker du oftest? *(Sett ett kryss pr. linje)*

	Bruker ikke	Meieri-smør	Hard margarin	Myk/lett margarin	Oljer	Annet
På brødet	☐	☐	☐	☐	☐	☐
I matlagingen	☐	☐	☐	☐	☐	☐
	1	2	3	4	5	6

7.3 Bruker du følgende kosttilskudd:

	Ja, daglig	Iblant	Nei
Tran, trankapsler, fiskeoljekapsler?	☐	☐	☐
Vitamin- og/eller mineraltilskudd?	☐	☐	☐

7.4 Hvor mye drikker du vanligvis av følgende?
(Sett ett kryss pr. linje)

	Sjelden /aldri	1-6 glass pr.uke	1 glass pr.dag	2-3 glass pr.dag	4 glass el. mer pr.dag
Helmelk, kefir, yoghurt	☐	☐	☐	☐	☐
Lettmelk, cultura, lettyoghurt	☐	☐	☐	☐	☐
Skummet melk (sur/søt)	☐	☐	☐	☐	☐
Ekstra lettmelk	☐	☐	☐	☐	☐
Fruktjuice	☐	☐	☐	☐	☐
Vann	☐	☐	☐	☐	☐
Farris, Ramløsa e.l.	☐	☐	☐	☐	☐
Cola-holdig leskedrikk	☐	☐	☐	☐	☐
Annen brus/leskedrikk	☐	☐	☐	☐	☐
	1	2	3	4	5

7.5 Drikker du vanligvis brus/cola: Med sukker ☐ 1 Uten sukker ☐ 2

7.6 Hvor mange kopper kaffe og te drikker du daglig? *Antall kopper*
(Sett 0 for de typene du ikke drikker daglig)

Filterkaffe ☐☐

Kokekaffe/trykkanne ☐☐

Annen kaffe ☐☐

Te ☐☐

7.7 Omtrent hvor ofte har du i løpet av det siste året drukket alkohol?
(Lettøl og alkoholfritt øl regnes ikke med)

Har aldri drukket alkohol	Har ikke drukket alkohol siste år	Noen få ganger siste år	Omtrent 1 gang i måneden
☐ 1	☐ 2	☐ 3	☐ 4
2-3 ganger pr. måned	**ca. 1 gang i uka**	**2-3 ganger i uka**	**4-7 ganger i uka**
☐ 5	☐ 6	☐ 7	☐ 8

Til dem som har drukket siste år:

7.8 Når du har drukket alkohol, hvor mange glass eller drinker har du vanligvis drukket? *Antall* ☐☐

7.9 Omtrent hvor mange ganger i løpet av det siste året har du drukket så mye som minst 5 glass eller drinker i løpet av ett døgn? *Antall ganger* ☐☐

7.10 Når du drikker, drikker du da vanligvis: *(Sett ett eller flere kryss)*

Øl ☐ Vin ☐ Brennevin ☐

8. RØYKING

8.1 Hvor lenge er du vanligvis daglig tilstede i røykfylt rom? *Antall hele timer* ☐☐

8.2 Røykte noen av de voksne hjemme da du vokste opp? JA ☐ NEI ☐

8.3 Bor du, eller har du bodd, sammen med noen dagligrøykere etter at du fylte 20 år? JA ☐ NEI ☐

8.4 Har du røykt/røyker du daglig? Ja, nå ☐ Ja, tidligere ☐ Aldri ☐

Hvis ALDRI: Hopp til spørsmål 9 (UTDANNING OG ARBEID)

8.5 Hvis du røyker daglig nå, røyker du: JA NEI

Sigaretter? ☐ ☐

Sigarer/sigarillos? ☐ ☐

Pipe? ☐ ☐

8.6 Hvis du har røykt daglig tidligere, hvor lenge er det siden du sluttet? *Antall år* ☐☐

8.7 Hvis du røyker daglig nå eller har røykt tidligere:

Hvor mange sigaretter røyker eller røykte du vanligvis daglig? *Antall sigaretter* ☐☐

Hvor gammel var du da du begynte å røyke daglig? *Alder i år* ☐☐

Hvor mange år til sammen har du røykt daglig? *Antall år* ☐☐

9. UTDANNING OG ARBEID

9.1 Hvor mange års skolegang har du gjennomført? *Antall år* ☐☐
(Ta med alle år du har gått på skole eller studert)

9.2 Er du i inntektsgivende arbeid?

Ja, full tid ☐ 1 Ja, deltid ☐ 2 Nei ☐ 3

9.3 Beskriv virksomheten på det arbeidsstedet (avdelingen) der du utførte inntektsgivende arbeid i lengst tid de siste 12 mnd. *(F.eks. regnskapsbyrå, ungdomsskole, barneavd. på sykehus, snekkerverksted, bilverksted, bank, dagligvarehandel e.l.)*

Virksomhet: _____
Hvis pensjonert, skriv tidligere hovedvirksomhet og yrke. Gjelder også 9.4

9.4 Hvilket yrke/tittel har eller hadde du på dette arbeidsstedet?
(F.eks. sekretær, lærer, industriarbeider, barnepleier, møbelsnekker, avdelingsleder, selger, sjåfør e.l.)

Yrke: _____

9.5 Arbeider du i ditt hovedyrke som selvstendig, som ansatt eller som familiemedlem uten fast avtalt lønn?

Selvstendig ☐ Ansatt ☐ Familiemedlem ☐

9.6 Mener du at du står i fare for å miste ditt nåværende arbeid eller inntekt de nærmeste 2 årene? JA ☐ NEI ☐

9.7 Mottar du noen av følgende ytelser?

	JA	NEI
Sykepenger (er sykmeldt)	☐	☐
Alderstrygd, førtidspensjon (AFP) eller etterlattepensjon	☐	☐
Rehabiliterings-/attføringspenger	☐	☐
Uførepensjon (hel eller delvis)	☐	☐
Dagpenger under arbeidsledighet	☐	☐
Sosialhjelp/-stønad	☐	☐
Overgangsstønad for enslige forsørgere	☐	☐

Health survey

Personal Invitation

Don't write here

5.3 (Municipality) (County) (Country)

9.3 (Business) 9.4 (Occupation) 14.7 (Mark)

1. YOUR OWN HEALTH

1.1 What is your current state of health? *(Tick one only)*

Poor ☐ 1 | Not so good ☐ 2 | Good ☐ 3 | Very good ☐ 4

1.2 Do you have, or have you had?:

	Yes	No	Age first time
Asthma	☐	☐	
Hay fever	☐	☐	
Chronic bronchitis/emphysema	☐	☐	
Diabetes	☐	☐	
Osteoporosis	☐	☐	
Fibromyalgia/chronic pain syndrome	☐	☐	
Psychological problems for which you have sought help	☐	☐	
A heart attack	☐	☐	
Angina pectoris (heart cramp)	☐	☐	
Cerebral stroke/brain haemorrhage	☐	☐	

1.3 Have you noticed attacks of sudden changes in your pulse or heart rhythm in the last year? Yes ☐ No ☐

1.4 Do you get pain or discomfort in the chest when:
Walking up hills, stairs or walking fast on level ground? Yes ☐ No ☐

1.5 If you get such pain, do you usually:

Stop? ☐ 1 | Slow down? ☐ 2 | Carry on at the same pace? ☐ 3

1.6 If you stop, does the pain disappear within 10 minutes? Yes ☐ No ☐

1.7 Can such pain occur even if you are at rest? Yes ☐ No ☐

2. MUSCULAR AND SKELETAL COMPLAINTS

2.1 Have you suffered from pain and/or stiffness in muscles and joints during the last 4 weeks?
(Give duration only if you have had problems)

	No complaint	Some complaint	Severe complaint	Duration: Up to 2 weeks	Duration: 2 weeks or more
Neck/shoulders	☐	☐	☐	☐	☐
Arms, hands	☐	☐	☐	☐	☐
Upper part of your back...	☐	☐	☐	☐	☐
Lumbar region	☐	☐	☐	☐	☐
Hips, legs, feet	☐	☐	☐	☐	☐
Other places	☐	☐	☐	☐	☐
	1	2	3	1	2

2.2 Have you ever had:

	Yes	No	Age last time
Fracture in the wrist/forearm	☐	☐	
Hip fracture?	☐	☐	

3. OTHER COMPLAINTS

3.1 Below is a list of various problems. Have you experienced any of this during the last week (including today)?
(Tick once for each complaint)

	No complaint	Little complaint	Pretty much	Very much
Sudden fear without reason	☐	☐	☐	☐
Feel afraid or anxious	☐	☐	☐	☐
Faintness or dizziness	☐	☐	☐	☐
Feel tense or upset	☐	☐	☐	☐
Tend to blame yourself	☐	☐	☐	☐
Sleeping problems	☐	☐	☐	☐
Depressed, sad	☐	☐	☐	☐
Feeling of being useless, worthless	☐	☐	☐	☐
Feeling that everything is a struggle	☐	☐	☐	☐
Feeling of hopelessness with regard to the future	☐	☐	☐	☐
	1	2	3	4

4. USE OF HEALTH SERVICES

4.1 How many times in the last 12 months have you been to/used:
(Tick once for each line)

	None	1-3 times	4 or more
A general medical practitioner (GP)	☐	☐	☐
Medical officer at work	☐	☐	☐
Psychologist or psychiatrist *(private or out-patient clinic)*	☐	☐	☐
Other specialist *(private or out-patient clinic)*	☐	☐	☐
Emergency GP *(private or public)*	☐	☐	☐
Hospital admission	☐	☐	☐
Home nursing care	☐	☐	☐
Physiotherapist	☐	☐	☐
Chiropractor	☐	☐	☐
Dentist	☐	☐	☐
Alternative practitioner	☐	☐	☐

5. CHILDHOOD/YOUTH AND AFFILIATION

5.1 How long altogether have you lived in the county? ☐☐ year
(Put 0 if less than half a year)

5.2 How long altogether have you lived in the municipality? ☐☐ year
(Put 0 if less than half a year)

5.3 Where did you live most of the time before the age of 16?
(Tick one option and specify)

Same municipality .... ☐ 1

Another municipality in the county ..... ☐ 2 Which one: _____

Another county in Norway ☐ 3 Which one: _____

Outside Norway ..... ☐ 4 Country:: _____

5.4 Have you moved within the last five years?

No ☐ 1 | Yes, one time ☐ 2 | Yes, more than once ☐ 3

6. BODY WEIGHT

6.1 Estimate your body weight when you were 25 years old: ☐☐☐ kg

7. FOOD AND BEVERAGES

7.1 How often do you usually eat these foods? *(Tick once per line)*

	Rarely /never	1-3 times /month	1-3 times /week	4-6 times /week	1-2 times /day	3 times or more /day
Fruit, berries	☐	☐	☐	☐	☐	☐
Cheese *(all types)*	☐	☐	☐	☐	☐	☐
Potatoes	☐	☐	☐	☐	☐	☐
Boiled vegetables	☐	☐	☐	☐	☐	☐
Fresh vegetables/salad	☐	☐	☐	☐	☐	☐
Fatty fish *(e.g. salmon, trout, mackerel, herring)*	☐	☐	☐	☐	☐	☐
	1	2	3	4	5	6

7.2 What type of fat do you usually use? *(Tick once per line)*

	Don't use	Butter	Hard margarine	Soft/light margarine	Oils	Other
On bread	☐	☐	☐	☐	☐	☐
For cooking	☐	☐	☐	☐	☐	☐
	1	2	3	4	5	6

7.3 Do you use the following dietary supplements:

	Yes, daily	Sometimes	No
Cod liver oil, fish oil capsules	☐	☐	☐
Vitamins and/or mineral supplements?	☐	☐	☐

7.4 How much of the following do you usually drink? *(Tick once per line)*

	Rarely /never	1-6 glasses /week	1 glass /day	2-3 glasses /day	4 glasses or more /day
Full milk, full-fat curdled milk, yoghurt	☐	☐	☐	☐	☐
Semi-skimmed milk, semi-skimmed curdled milk,low-fat yoghurt	☐	☐	☐	☐	☐
Skimmed milk, skimmed curdled milk	☐	☐	☐	☐	☐
Extra semi-skimmed milk	☐	☐	☐	☐	☐
Juice	☐	☐	☐	☐	☐
Water	☐	☐	☐	☐	☐
Mineral water (e.g. Farris, Ramløsa etc)	☐	☐	☐	☐	☐
Cola-containing soft drink	☐	☐	☐	☐	☐
Other soda/soft drink	☐	☐	☐	☐	☐
	1	2	3	4	5

7.5 Do you usually drink soft drink: with sugar ☐ 1 without sugar ☐ 2

7.6 How many cups of coffee and tea do you drink daily? *Number of cups*
(Put 0 for the types you don't drink daily)

Filtered coffee ..... ☐☐

Boiled coffee/coarsely ground coffee for brewing ..... ☐☐

Other type of coffee ..... ☐☐

Tea ..... ☐☐

7.7 Approximately how often have you during the last year consumed alcohol? *(Do not count low-alcohol and alcohol-free beer)*

Never consumed alcohol ☐ 1	Have not consumed alcohol last year ☐ 2	A few times last year ☐ 3	About 1 time a month ☐ 4
2-3 times per month ☐ 5	About1 time a week ☐ 6	2-3 times a week ☐ 7	4-7 times a week ☐ 8

To those who have consumed the last year:

7.8 When you drink alcohol, how many glasses or drinks do you normally drink? *number* ☐☐

7.9 Approximately how many times during the last year have you consumed alcohol equivalent to 5 glasses or drinks within 24 hours? *Number of times* ☐☐

7.10 When you drink, do you normally drink: *(Tick one or more)*

Beer ☐ Wine ☐ Spirits ☐

8. SMOKING

8.1 How many hours a day do you normally spend in smoke-filled rooms? *Number of total hours* ☐☐

	Yes	No
8.2 Did any of the adults smoke at home while you were growing up?	☐	☐
8.3 Do you currently, or did you previously live together with a daily smoker after your 20th birthday?	☐	☐

	Yes, now	Yes, previously	Never
8.4 Did you/do you smoke daily?	☐	☐	☐

If NEVER: Go to question 9 : (EDUCATION AND WORK)

8.5 If you smoke daily now, do you smoke:	Yes	No
Cigarettes?	☐	☐
Cigars/cigarillos?	☐	☐
A pipe?	☐	☐

8.6 If you previously smoked daily, how long is it since you stopped? *Number of years* ☐☐

8.7 If you currently smoke, or have smoked before:

How many cigarettes do you or did you normally smoke per day? *Number of cigarettes* ☐☐

How old were you when you began smoking daily? *Age in years* ☐☐

How many years in all have you smoked daily? *Number of years* ☐☐

9. EDUCATION AND WORK

9.1 How many years of education have you completed? *Number of years* ☐☐
(Include all the years you have attended school or studied)

9.2 Do you currently have paid work?

Yes, full-time ☐ 1 Yes, part-time ☐ 2 No ☐ 3

9.3 Describe the activity at the workplace where you had paid work for the longest period in the last 12 months. *(e.g. Accountancy firm, school, paediatric department, carpentry workshop, garage, bank, grocery store, etc.)*

Business: _____
If retired, enter the former business and occupation. Also applies to 9.4

9.4 Which occupation/title have or had you at this workplace? *(e.g. Secretary, teacher, industrial worker, nurse, carpenter, manager, salesman, driver, etc.)*

Occupation: _____

9.5 In your main occupation, do you work as self-employed, as an employee or family member without regular salary?

Self-employed ☐ Employee ☐ Family member ☐

	Yes	No
9.6 Do you believe that you are in danger of losing your current work or income within the next two years?	☐	☐

9.7 Do you receive any of the following benefits?	Yes	No
Sickness benefit (are on sick leave)	☐	☐
Old age pension, early retirement (AFP) or survivor pension	☐	☐
Rehabilitation/reintegration benefit	☐	☐
Disability pension (full or partial)	☐	☐
Unemployment benefits during unemployment	☐	☐
Social welfare benefits	☐	☐
Transition benefit for single parents	☐	☐

10. EXERCISE AND PHYSICAL ACTIVITY

10.1 How has your physical activity in leisure time been during this last year?

Think of a weekly average for the year.
Time spent going to work is count as leisure time. Answer both questions.

	Hours per week: None	Less than 1	1-2	3 or more
Light activity *(not sweating/out of breath)*...	☐	☐	☐	☐
Hard physical activity *(sweating/out of breath)*.....	☐ 1	☐ 2	☐ 3	☐ 4

10.2 Indicate exercise and physical exertion in your leisure time. If activity varies much e.g. between summer and winter, then give an average. The question refers only to the last year.

(Tick the most appropriate box)

Reading, watching television or other sedentary activity? ..... ☐ 1

Walking, cycling or other forms of exercise at least 4 hours a week? ..... ☐ 2
(Include walking or cycling to work, Sunday walk/stroll,etc.)

Participation in recreational sports, heavy gardening, etc.? ☐ 3
(Note: duration of activity at least 4 hours a week)

Participation in hard training or sports competitions, regularly several times a week? ..... ☐ 4

11. FAMILY AND FRIENDS

11.1 Do you live with:

	Yes	No
Spouse/partner?.....	☐	☐

11.2 How many good friends do you have? *Number of friends* ☐☐

Count the ones you can talk confidentially with and who can give you help when you need it. Do not count people you live with, but do include other relatives.

11.3 How much interest do people show for what you do?

(Tick only once)

Great interest	Some interest	Little interest	No interest	Uncertain
☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

11.4 How many associations, sport clubs,groups, religious communities or similar do you take part in? *Number* ☐☐

(Write 0 if none)

11.5 Do you feel that you can influence what happening in your local community where you live? *(Tick only once)*

Yes, a lot	Yes, some	Yes, a little	No	Never tried
☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

12. ILLNESS IN THE FAMILY

12.1 Have one or more of your parents or siblings had a heart attack (heart wound) or angina pectoris (heart cramp)? .....

Yes	No	Don't know
☐	☐	☐

12.2 Tick for the relatives who have or have had any of the illnesses: *(Tick for each line)*

	Mother	Father	Brother	Sister	Child	None of these
Cerebral stroke or brain haemorrhage	☐	☐	☐	☐	☐	☐
Myocardial infarction before age of 60 years	☐	☐	☐	☐	☐	☐
Asthma.....	☐	☐	☐	☐	☐	☐
Cancer	☐	☐	☐	☐	☐	☐
Diabetes	☐	☐	☐	☐	☐	☐

12.3 If any relatives have diabetes, at what age did they get diabetes (if for e.g. many siblings, consider the one who got it earliest in life):

Don't know, not applicable	Mother's age	Father's age	Brother's age	Sister's age	Child's age
☐	☐☐	☐☐	☐☐	☐☐	☐☐

13. USE OF MEDICINES

With medicines, we mean drugs purchased at pharmacies. Supplements and vitamins are not considered here.

13.1 Do you use:

	Now	Previously, but not now	Never used
Medications for high blood pressure	☐	☐	☐
Cholesterol-lowering medications	☐	☐	☐

13.2 How often have you during the last 4 weeks used the following medicines?

(Tick once for each line)

	Not used in the last 4 weeks	Less than every week	Every week but not daily	Daily
Painkillers without prescription	☐	☐	☐	☐
Painkillers with prescription	☐	☐	☐	☐
Sleeping pills	☐	☐	☐	☐
Tranquillizers	☐	☐	☐	☐
Antidepressants	☐	☐	☐	☐
Other prescription medicines ...	☐ 1	☐ 2	☐ 3	☐ 4

13.3 For those medicines you have checked in points 13.1 and 13.2, and that you've used during the last 4 weeks:

Enter the name and the reason that you are taking/have taken these (disease or symptom):

(Tick for each duration you have used the medicine)

Name of the medicine: *(one name per line)*	Reason for use of the medicine	How long have you used the medicine: Up to 1 year	1 year or more
		☐	☐
		☐	☐
		☐	☐
		☐	☐
		☐	☐
		☐	☐
		☐	☐

If there is not enough space here, you may continue on a separate sheet that you attach

14. THE REST OF THE FORM IS TO BE ANSWERED BY WOMEN ONLY

14.1 How old were you when you started menstruating? *Age in years* ☐☐

14.2 If you no longer menstruating, how old were you when you stopped menstruating? *Age in years* ☐☐

14.3 Are you pregnant at the moment?

Yes	No	Uncertain	Above fertile age
☐ 1	☐ 2	☐ 3	☐ 4

14.4 How many children have you given birth to? *Number of children* ☐☐

14.5 Do you use, or have you ever used?

(Tick once for each line)

	Now	Before, but not now	Never
Oral contraceptive pills/mini pill/ contraceptive injection	☐	☐	☐
Hormonal intrauterine device (IUD) *(not ordinary IUD)*..	☐	☐	☐
Estrogen *(tablets or patches)*	☐	☐	☐
Estrogen *(cream or suppositories)*	☐	☐	☐

14.6 If you use/have used prescription estrogen:

How long have you used it? *Number of years* ☐☐

14.7 If you use contraceptive pills, mini pill, contraceptive injection, hormonal IUD or estrogen, what brand do you use?

IE 050000 - 1042-1 - 24.000 - Beyer Hecos 02.01

Appendix E

Questionnaire 1, the 6th Tromsø Study 2007-08

Norwegian version

English version, preliminary translation
(the final version will be made available
at www.tromsostudy.com)

Tromsø-undersøkelsen

Skjemaet skal leses optisk. Vennligst bruk blå eller sort penn. Du kan ikke bruke komma, bruk blokkbokstaver.

2007 – 2008 KONFIDENSIELT

HELSE OG SYKDOMMER

1 **Hvordan vurderer du din egen helse sånn i alminnelighet?**

- ☐ Meget god
- ☐ God
- ☐ Verken god eller dårlig
- ☐ Dårlig
- ☐ Meget dårlig

2 **Hvordan synes du at helsen din er sammenlignet med andre på din alder?**

- ☐ Mye bedre
- ☐ Litt bedre
- ☐ Omtrent lik
- ☐ Litt dårligere
- ☐ Mye dårligere

3 **Har du eller har du hatt?**

	Ja	Nei	Alder første gang
Hjerteinfarkt	☐	☐	
Angina pectoris *(hjertekrampe)*	☐	☐	
Hjerneslag/hjerneblødning	☐	☐	
Hjerteflimmer *(atrieflimmer)*	☐	☐	
Høyt blodtrykk	☐	☐	
Beinskjørhet *(osteoporose)*	☐	☐	
Astma	☐	☐	
Kronisk bronkitt/emfysem/KOLS	☐	☐	
Diabetes	☐	☐	
Psykiske plager *(som du har søkt hjelp for)*	☐	☐	
Lavt stoffskifte	☐	☐	
Nyresykdom, unntatt urinveisinfeksjon	☐	☐	
Migrene	☐	☐	

4 **Har du langvarige eller stadig tilbakevendende smerter som har vart i 3 måneder eller mer?**

☐ Ja ☐ Nei

5 **Hvor ofte har du vært plaget av søvnløshet de siste 12 måneder?**

- ☐ Aldri, eller noen få ganger
- ☐ 1-3 ganger i måneden
- ☐ Omtrent 1 gang i uken
- ☐ Mer enn 1 gang i uken

6 **Under finner du en liste over ulike problemer. Har du opplevd noe av dette den siste uken (til og med i dag)?** (Sett ett kryss for hver plage)

	Ikke plaget	Litt plaget	Ganske mye	Veldig mye
Plutselig frykt uten grunn	☐	☐	☐	☐
Føler deg redd eller engstelig	☐	☐	☐	☐
Matthet eller svimmelhet	☐	☐	☐	☐
Føler deg anspent eller oppjaget	☐	☐	☐	☐
Lett for å klandre deg selv	☐	☐	☐	☐
Søvnproblemer	☐	☐	☐	☐
Nedtrykt, tungsindig	☐	☐	☐	☐
Følelse av å være unyttig, lite verd	☐	☐	☐	☐
Følelse av at alt er et slit	☐	☐	☐	☐
Følelse av håpløshet mht. framtida	☐	☐	☐	☐

BRUK AV HELSETJENESTER

7 **Har du i løpet av de siste 12 måneder vært hos:** Hvis JA; Hvor mange ganger?

	Ja	Nei	Ant ggr
Fastlege/allmennlege	☐	☐	
Psykiater/psykolog	☐	☐	
Legespesialist utenfor sykehus *(utenom fastlege/allmennlege/psykiater)*	☐	☐	
Fysioterapeut	☐	☐	
Kiropraktor	☐	☐	
Annen behandler *(homøopat, akupunktør, fotsoneterapeut, naturmedisiner, håndspålegger, healer, synsk el.l)*	☐	☐	
Tannlege/tannpleier	☐	☐	

8 **Har du i løpet av de siste 12 måneder vært på sykehus?**

	Ja	Nei	Ant ggr
Innlagt på sykehus	☐	☐	
Konsultasjon ved sykehus uten innleggelse;			
Ved psykiatrisk poliklinikk	☐	☐	
Ved annen sykehuspoliklinikk	☐	☐	

9 **Har du gjennomgått noen form for operasjon i løpet av de siste 3 årene?**

☐ Ja ☐ Nei

BRUK AV MEDISINER

10 **Bruker du, eller har du brukt, noen av følgende medisiner?** (Sett ett kryss for hver linje)

	Aldri brukt	Nå	Før	Alder første gang
Medisin mot høyt blodtrykk	☐	☐	☐	
Kolesterolsenkende medisin	☐	☐	☐	
Medisin mot hjertesykdom	☐	☐	☐	
Vanndrivende medisin	☐	☐	☐	
Medisin mot beinskjørhet *(osteoporose)*	☐	☐	☐	
Insulin	☐	☐	☐	
Diabetesmedisin *(tabletter)*	☐	☐	☐	
Stoffskiftemedisinene Thyroxin/levaxin	☐	☐	☐	

11 **Hvor ofte har du i løpet av de siste 4 ukene brukt følgende medisiner?** (Sett ett kryss pr linje)

	Ikke brukt siste 4 uker	Sjeldnere enn hver uke	Hver uke, men ikke daglig	Daglig
Smertestillende på resept	☐	☐	☐	☐
Smertestillende reseptfrie	☐	☐	☐	☐
Sovemidler	☐	☐	☐	☐
Beroligende medisiner	☐	☐	☐	☐
Medisin mot depresjon	☐	☐	☐	☐

12 **Skriv ned alle medisiner – både de med og uten resept – som du har brukt regelmessig i siste 4 ukers periode.** (Ikke regn med vitaminer, mineraler, urter, naturmedisin, andre kosttilskudd etc.)

Får du ikke plass til alle medisiner, bruk eget ark.

VED FRAMMØTE vil du bli spurt om du har brukt antibiotika eller smertestillende medisiner de siste 24 timene. Om du har det, vil vi be om at du oppgir preparat, styrke, dose og tidspunkt

FAMILIE OG VENNER

13 **Hvem bor du sammen med?** (Sett kryss for hvert spørsmål og angi antall)

	Ja	Nei	Antall
Ektefelle/samboer	☐	☐	
Andre personer over 18 år	☐	☐	
Personer under 18 år	☐	☐	

14 **Kryss av for de slektninger som har eller har hatt**

	Foreldre	Barn	Søsken
Hjerteinfarkt	☐	☐	☐
Hjerteinfarkt før fylte 60 år	☐	☐	☐
Angina pectoris *(hjertekrampe)*	☐	☐	☐
Hjerneslag/hjerneblødning	☐	☐	☐
Beinskjørhet *(osteoporose)*	☐	☐	☐
Magesår/tolvfingertarmsår	☐	☐	☐
Astma	☐	☐	☐
Diabetes	☐	☐	☐
Demens	☐	☐	☐
Psykiske plager	☐	☐	☐
Rusproblemer	☐	☐	☐

15 **Har du nok venner som kan gi deg hjelp når du trenger det?**

☐ Ja ☐ Nei

16 **Har du nok venner som du kan snakke fortrolig med?**

☐ Ja ☐ Nei

17 **Hvor ofte tar du vanligvis del i foreningsvirksomhet som for eksempel syklubb, idrettslag, politiske lag, religiøse eller andre foreninger?**

☐ Aldri, eller noen få ganger i året
☐ 1-2 ganger i måneden
☐ Omtrent 1 gang i uken
☐ Mer enn en gang i uken

ARBEID, TRYGD OG INNTEKT

18 **Hva er din høyeste fullførte utdanning?** (Sett ett kryss)

☐ Grunnskole, framhaldsskole eller folkehøyskole
☐ Yrkesfaglig videregående, yrkesskole eller realskole
☐ Allmennfaglig videregående skole eller gymnas
☐ Høyskole eller universitet, mindre enn 4 år
☐ Høyskole eller universitet, 4 år eller mer

19 **Hva er din hovedaktivitet?** (Sett ett kryss)

☐ Yrkesaktiv heltid
☐ Yrkesaktiv deltid
☐ Arbeidsledig
☐ Hjemmeværende
☐ Pensjonist/trygdet
☐ Student/militærtjeneste

20 **Mottar du noen av følgende ytelser?**

- ☐ Alderstrygd, førtidspensjon (AFP) eller etterlattepensjon
- ☐ Sykepenger (er sykemeldt)
- ☐ Rehabiliterings-/attføringspenger
- ☐ Uføreytelse/pensjon, hel
- ☐ Uføreytelse/pensjon, delvis
- ☐ Dagpenger under arbeidsledighet
- ☐ Overgangstønad
- ☐ Sosialhjelp/-stønad

21 **Hvor høy var husholdningens samlede bruttoinntekt siste år?** Ta med alle inntekter fra arbeid, trygder, sosialhjelp og lignende.

- ☐ Under 125 000 kr
- ☐ 125 000-200 000 kr
- ☐ 201 000-300 000 kr
- ☐ 301 000-400 000 kr
- ☐ 401 000-550 000 kr
- ☐ 551 000-700 000 kr
- ☐ 701 000 -850 000 kr
- ☐ Over 850 000 kr

22 **Arbeider du utendørs minst 25 % av tiden, eller i lokaler med lav temperatur, som for eksempel lager-/industrihaller?**

- ☐ Ja
- ☐ Nei

FYSISK AKTIVITET

23 **Hvis du er i lønnet eller ulønnet arbeid, hvordan vil du beskrive arbeidet ditt?**

- ☐ For det meste stillesittende arbeid *(f.eks. skrivebordsarbeid, montering)*
- ☐ Arbeid som krever at du går mye *(f.eks ekspeditørarbeid, lett industriarbeid, undervisning)*
- ☐ Arbeid der du går og løfter mye *(f.eks postbud, pleier, bygningsarbeider)*
- ☐ Tungt kroppsarbeid

24 **Angi bevegelse og kroppslig anstrengelse i din fritid. Hvis aktiviteten varierer meget f eks mellom sommer og vinter, så ta et gjennomsnitt. Spørsmålet gjelder bare det siste året.** (Sett kryss i den ruta som passer best)

- ☐ Leser, ser på fjernsyn eller annen stillesittende beskjeftigelse
- ☐ Spaserer, sykler eller beveger deg på annen måte minst 4 timer i uken *(her skal du også regne med gang eller sykling til arbeidsstedet, søndagsturer med mer)*
- ☐ Driver mosjonsidrett, tyngre hagearbeid, snømåking e.l. *(merk at aktiviteten skal vare minst 4 timer i uka)*
- ☐ Trener hardt eller driver konkurranseidrett regelmessig og flere ganger i uka

25 **Hvor ofte driver du mosjon?** (Med mosjon mener vi at du f.eks går en tur, går på ski, svømmer eller driver trening/idrett)

- ☐ Aldri
- ☐ Sjeldnere enn en gang i uken
- ☐ En gang i uken
- ☐ 2-3 ganger i uken
- ☐ omtrent hver dag

26 **Hvor hardt mosjonerer du da i gjennomsnitt?**

- ☐ Tar det rolig uten å bli andpusten eller svett.
- ☐ Tar det så hardt at jeg blir andpusten og svett
- ☐ Tar meg nesten helt ut

27 **Hvor lenge holder du på hver gang i gjennomsnitt ?**

- ☐ Mindre enn 15 minutter
- ☐ 15-29 minutter
- ☐ 30 minutter – 1 time
- ☐ Mer enn 1 time

ALKOHOL OG TOBAKK

28 **Hvor ofte drikker du alkohol?**

- ☐ Aldri
- ☐ Månedlig eller sjeldnere
- ☐ 2-4 ganger hver måned
- ☐ 2-3 ganger pr. uke
- ☐ 4 eller flere ganger pr.uke

29 **Hvor mange enheter alkohol** (en øl, et glass vin, eller en drink) **tar du vanligvis når du drikker?**

- ☐ 1-2
- ☐ 3-4
- ☐ 5-6
- ☐ 7-9
- ☐ 10 eller flere

30 **Hvor ofte drikker du 6 eller flere enheter alkohol ved en anledning?**

- ☐ aldri
- ☐ sjeldnere enn månedlig
- ☐ månedlig
- ☐ ukentlig
- ☐ daglig eller nesten daglig

31 **Røyker du av og til, men ikke daglig?**

- ☐ Ja
- ☐ Nei

32 **Har du røykt/røyker du daglig?**

- ☐ Ja, nå
- ☐ Ja, tidligere
- ☐ Aldri

33 **Hvis du har røykt daglig tidligere, hvor lenge er det siden du sluttet?**

Antall år ☐☐

34 **Hvis du røyker daglig nå eller har røykt tidligere: Hvor mange sigaretter røyker eller røykte du vanligvis daglig?**

Antall sigaretter ☐☐

35 **Hvor gammel var du da du begynte å røyke daglig?**

Antall år ☐☐

36 **Hvor mange år til sammen har du røykt daglig?**

Antall år ☐☐

37 **Bruker du, eller har du brukt, snus eller skrå?**

- ☐ Nei, aldri
- ☐ Ja, men jeg har sluttet
- ☐ Ja, av og til
- ☐ Ja, daglig

KOSTHOLD

38 **Spiser du vanligvis frokost hver dag?**

☐ Ja ☐ Nei

39 **Hvor mange enheter frukt og grønnsaker spiser du i gjennomsnitt per dag?** (Med enhet menes f.eks. en frukt, glass juice, potet, porsjon grønnsaker)

Antall enheter ☐☐

40 **Hvor mange ganger i uken spiser du varm middag?**

Antall ☐☐

41 **Hvor ofte spiser du vanligvis disse matvarene?**
(Sett ett kryss pr linje)

	0-1 g pr. mnd	2-3 g pr.mnd	1-3 g pr.uke	4-6 g pr.uke	1-2 g pr. dag
Poteter	☐	☐	☐	☐	☐
Pasta/ris	☐	☐	☐	☐	☐
Kjøtt *(ikke kvernet)*	☐	☐	☐	☐	☐
Kvernet kjøtt *(pølser, hamburger o.l)*	☐	☐	☐	☐	☐
Grønnsaker, frukt, bær	☐	☐	☐	☐	☐
Mager fisk	☐	☐	☐	☐	☐
Feit fisk *(f.eks.laks, ørret, makrell, sild, kveite,uer)*	☐	☐	☐	☐	☐

42 **Hvor mye drikker du vanligvis av følgende?**
(Sett ett kryss pr. linje)

	Sjelden/ aldri	1-6 glass pr. uke	1 glass pr. dag	2-3 glass pr. dag	4 glass el. mer pr. dag
Melk, kefir, yoghurt	☐	☐	☐	☐	☐
Fruktjuice	☐	☐	☐	☐	☐
Brus/leskedrikker med sukker	☐	☐	☐	☐	☐

43 **Hvor mange kopper kaffe og te drikker du daglig?**
(sett 0 for de typene du ikke drikker daglig)

	Antall kopper
Filterkaffe	☐☐
Kokekaffe/presskanne	☐☐
Annen kaffe	☐☐
Te	☐☐

44 **Hvor ofte spiser du vanligvis fiskelever?**
(For eksempel i mølje)

☐ Sjelden/aldri ☐ 1-3 g i året ☐ 4-6 g i året
☐ 7-12 g i året ☐ Oftere

45 **Bruker du følgende kosttilskudd?**

	Daglig	Iblant	Nei
Tran, trankapsler	☐	☐	☐
Omega 3 kapsler *(fiskeolje,selolje)*	☐	☐	☐
Kalktabletter	☐	☐	☐

SPØRSMÅL TIL KVINNER

46 **Er du gravid nå?**

☐ Ja ☐ Nei ☐ Usikker

47 **Hvor mange barn har du født?**

Antall ☐☐

48 **Hvis du har født, fyll ut for hvert barn: fødselsår og vekt samt hvor mange måneder du ammet.**
(Angi så godt som du kan)

Barn	Fødselsår	Fødselsvekt i gram	Ammet ant.mnd
1	☐☐☐☐	☐☐☐☐	☐☐
2	☐☐☐☐	☐☐☐☐	☐☐
3	☐☐☐☐	☐☐☐☐	☐☐
4	☐☐☐☐	☐☐☐☐	☐☐
5	☐☐☐☐	☐☐☐☐	☐☐
6	☐☐☐☐	☐☐☐☐	☐☐

49 **Har du i forbindelse med svangerskap hatt for høyt blodtrykk?**

☐ Ja ☐ Nei

50 **Hvis Ja, i hvilket svangerskap?**

☐ Første ☐ Senere

51 **Har du i forbindelse med svangerskap hatt protein (eggehvite) i urinen?**

☐ Ja ☐ Nei

52 **Hvis Ja, i hvilket svangerskap?**

☐ Første ☐ Senere

53 **Ble noen av disse barna født mer enn en måned for tidlig (før termin) pga. svangerskapsforgiftning?**

☐ Ja ☐ Nei

54 **Hvis Ja, hvilke(t) barn**

Barn 1	Barn 2	Barn 3	Barn 4	Barn 5	Barn 6
☐	☐	☐	☐	☐	☐

55 **Hvor gammel var du da du fikk menstruasjon første gang?**

Antall år ☐☐

56 **Bruker du for tiden reseptpliktige legemidler som påvirker menstruasjonen?**

P-pille, hormonspiral eller lignende ☐ Ja ☐ Nei
Hormonpreparat for overgangs-alderen ☐ Ja ☐ Nei

VED FRAMMØTE vil du få utfyllende spørsmål om menstruasjon og eventuell bruk av hormoner. Skriv gjerne ned på et papir navn på hormonpreparater du har brukt, og ta det med deg. Du vil også bli spurt om din menstruasjon har opphørt og eventuelt når og hvorfor.

LUNDBLAD MEDIA AS, TROMSØ, 77 75 32 50 - ONR 082222

Tromsø-undersøkelsen

The Tromsø Study

The form will be read electronically. Please use a blue or black pen
You can not use comas, use upper-case letters.

2007 - 2008 Confidential

HEALTH AND DISEASES

1 **How do you in general consider your own health to be?**

- ☐ Very good
- ☐ Good
- ☐ Neither good nor bad
- ☐ Bad
- ☐ Very bad

2 **How is your health compared to others in your age?**

- ☐ Much better
- ☐ A little better
- ☐ About the same
- ☐ A little worse
- ☐ Much worse

3 **Do you have, or have you had?**

	Yes	No	Age first time
A heart attack	☐	☐	
Angina pectoris *(heart cramp)*	☐	☐	
Cerebral stroke/brain hemorrhage	☐	☐	
Atrial fibrillation	☐	☐	
High blood pressure	☐	☐	
Osteoporosis	☐	☐	
Asthma	☐	☐	
Chronic bronchitis/Emphysyma/COPD	☐	☐	
Diabetes mellitus	☐	☐	
Psychological problems *(for which you have sought help)*	☐	☐	
Low metabolism	☐	☐	
Kidney disease, *not including urinary tract infection (UTI)*	☐	☐	
Migraine	☐	☐	

4 **Do you have persistent or constantly recurring pain that has lasted for 3 months or more?**

☐ Yes ☐ No

5 **How often have you suffered from sleeplessness during the last 12 months?**

- ☐ Never, or just a few times
- ☐ 1-3 times a month
- ☐ Approximately once a week
- ☐ More that once a week

6 **Below you find a list of different situations. Have you experienced some of them in the last week (including today)?** (Tick once for each complaint)

	No complaint	Little complaint	Pretty much	Very much
Sudden fear without reason	☐	☐	☐	☐
You felt afraid or worried	☐	☐	☐	☐
Faintness or dizziness	☐	☐	☐	☐
You felt tense or upset	☐	☐	☐	☐
Easily blamed yourself	☐	☐	☐	☐
Sleeping problems	☐	☐	☐	☐
Depressed, sad	☐	☐	☐	☐
You felt useless, worthless	☐	☐	☐	☐
Feeling that life is a struggle	☐	☐	☐	☐
Feeling of hopelessness with regard to the future	☐	☐	☐	☐

USE OF HEALTH SERVICES

7 **Have you during the last 12 months visited:** If YES; how many times?

	Yes	No	No. of times
General practitioner (GP)	☐	☐	
Psychiatrist/psychologist	☐	☐	
Medical specialist outside hospital *(other than general practitioner/psychiatrist)*	☐	☐	
Physiotherapist	☐	☐	
Chiropractor	☐	☐	
Alternative practitioner *(homeopath, acupuncturist, foot zone therapist, herbal medical practitioner, laying on hands practitioner, healer, clairvoyant, etc.)*	☐	☐	
Dentist/dental service	☐	☐	

8 **Have you during the last 12 months been to a hospital?**

	Yes	No	No. of times
Admitted to a hospital	☐	☐	
Had consultation in a hospital without admission;			
At psychiatric out-patient clinic	☐	☐	
At another out-patient clinic	☐	☐	

9 **Have you undergone any surgery during the last 3 years?**

☐ Yes ☐ No

USE OF MEDICINE

10 **Do you take, or have you taken some of the following medications?** (Tick once for each line)

	Never used	Now	Earlier	Age first time
Medications for high blood pressure	☐	☐	☐	
Lipid lowering drugs	☐	☐	☐	
Medications for heart disease	☐	☐	☐	
Diuretics	☐	☐	☐	
Medications for osteoporosis	☐	☐	☐	
Insulin	☐	☐	☐	
Tablets for diabetes	☐	☐	☐	
Metabolic disorder medications Thyroxine/levaxin	☐	☐	☐	

11 **How often have you during the last 4 weeks used the following medications?**(Tick once for each line)

	Not used the last 4 weeks	Less than every week	Every week, but not daily	Daily
Painkillers with prescription	☐	☐	☐	☐
Painkillers without prescription	☐	☐	☐	☐
Sleeping pills	☐	☐	☐	☐
Tranquillizers	☐	☐	☐	☐
Antidepressants	☐	☐	☐	☐

12 **State the names of all medications -both those with or without prescription- which you have used regularly during the last 4 weeks.**
Do not include vitamins, minerals, herbs, natural remedies, other nutritional supplements, etc.

If the space is not enough for all medications, use an additional paper of your own.

When attending the survey centre you will be asked whether you have used antibiotics or painkillers the last 24 hours. If you have, you will be asked to provide the name of the drug, strength, dose and time of use.

FAMILY AND FRIENDS

13 **Who do you live with?** (Tick for each question and give the number)

	Yes	No	Number
Spouse/partner	☐	☐	
Other people older than 18 years	☐	☐	
People younger than 18 years	☐	☐	

14 **Tick for the relatives who have or have had**

	Parents	Children	Siblings
A heart attack	☐	☐	☐
A heart attack before age 60	☐	☐	☐
Angina pectoris *(heart cramp)*	☐	☐	☐
Cerebral stroke/brain haemorrhage	☐	☐	☐
Osteoporosis	☐	☐	☐
Stomach/duodenal ulcer	☐	☐	☐
Asthma	☐	☐	☐
Diabetes mellitus	☐	☐	☐
Dementia	☐	☐	☐
Psychological problems	☐	☐	☐
Problem with substance abuse	☐	☐	☐

15 **Do you have enough friends who can give you help when you need it?**

☐ Yes ☐ No

16 **Do you have enough friends whom you can talk confidentially with?**

☐ Yes ☐ No

17 **How often do you normally take part in organised gatherings, e.g. sports clubs, political meetings, religious or other associations?**

☐ Never, or just a few times a year
☐ 1-2 times a month
☐ Approximately once a week
☐ More than once a week

WORK, SOCIAL SECURITY AND INCOME

18 **What is the highest level of education you have completed?** (Tick once)

☐ Primary or secondary school
☐ Technical or vocational school
☐ High secondary school (A-level)
☐ College/university less than 4 years
☐ College/university 4 years or more

19 **What is your main activity?** (Tick once)

☐ Full time work ☐ Housekeeping
☐ Part time work ☐ Retired/benefit recipient
☐ Unemployed ☐ Student/military service

20 **Do you receive any of the following benefits?**

- ☐ Old-age, early retirement or survivor pension
- ☐ Sickness benefit (sick leave)
- ☐ Rehabilitation benefit
- ☐ Full disability pension
- ☐ Partial disability pension
- ☐ Unemployment benefits
- ☐ Transition benefit for single parents
- ☐ Social welfare benefits

21 **What was the households total taxable income last year?** Include income from work, social benefits and similar

- ☐ Less than 125 000 NOK
- ☐ 125 000-200 000 NOK
- ☐ 201 000-300 000 NOK
- ☐ 301 000-400 000 NOK
- ☐ 401 000-550 000 NOK
- ☐ 551 000-700 000 NOK
- ☐ 701 000 -850 000 NOK
- ☐ More than 850 000 NOK

22 **Do you work outdoor at least 25% of the time, or in cold buildings (e.g. storehouse/industry buildings)?**

- ☐ Yes
- ☐ No

PHYSICAL ACTIVITY

23 **If you have paid or unpaid work, which statement describes your work best?**

- ☐ Mostly sedentary work
  (e.g. office work, mounting)
- ☐ Work that requires a lot of walking
  (e.g. shop assistant, light industrial work, teaching)
- ☐ Work that requires a lot of walking and lifting
  (e.g. postman, nursing, construction)
- ☐ Heavy manual labour

24 **Describe your exercise and physical exertion in leisure time. If you activity varies much, e.g. between summer and winter, then give an average. The question refers only to the last year.** (Tick the one that fits best)

- ☐ Reading, watching TV, or other sedentary activity.
- ☐ Walking, cycling, or other forms of exercise at least 4 hours a week *(here including walking or cycling to place of work, Sunday-walking, etc.)*
- ☐ Participation in recreational sports, heavy gardening, etc. *(note:duration of activity at least 4 hours a week)*
- ☐ Participation in hard training or sports competitions, regularly several times a week.

25 **How often do you exercise?** (With exercise we mean for example walking, skiing, swimming or training/sports)

- ☐ Never
- ☐ Less than once a week
- ☐ Once a week
- ☐ 2-3 times a week
- ☐ Approximately every day

26 **How hard do you exercise on average?**

- ☐ Easy- do not become short-winded or sweaty
- ☐ You become short-winded and sweaty
- ☐ Hard- you become exhausted

27 **For how long time do you exercise every time on average?**

- ☐ Less than 15 minutes
- ☐ 15-29 minutes
- ☐ 30-60 minutes
- ☐ More than 1 hour

ALCOHOL AND TOBACCO

28 **How often do you drink alcohol?**

- ☐ Never
- ☐ Monthly or more infrequently
- ☐ 2-4 times a month
- ☐ 2-3 times a week
- ☐ 4 or more times a week

29 **How many units of alcohol** (a beer, a glass of wine or a drink) **do you usually drink when you drink alcohol?**

- ☐ 1-2
- ☐ 3-4
- ☐ 5-6
- ☐ 7-9
- ☐ 10 or more

30 **How often do you drink 6 units of alcohol or more in one occasion?**

- ☐ Never
- ☐ Less frequently than monthly
- ☐ Monthly
- ☐ Weekly
- ☐ Daily or almost daily

31 **Do you smoke sometimes, but not daily?**

- ☐ Yes
- ☐ No

32 **Do you/did you smoke daily?**

- ☐ Yes, now
- ☐ Yes, previously
- ☐ Never

33 **If you previously smoked daily, how long is it since you stopped?**

Number of years ☐☐

34 **If you currently smoke, or have smoked before: How many cigarettes do you or did you usually smoke per day?**

Number of cigarettes ☐☐

35 **How old were you when you began smoking daily?**

Number of years ☐☐

36 **How many years in all have you smoked daily?**

Number of years ☐☐

37 **Do you use or have you used snuff or chewing tobacco?**

- ☐ No, never
- ☐ Yes, previously
- ☐ Yes, sometimes
- ☐ Yes, daily

DIET

38 **Do you usually eat breakfast every day?**

☐ Yes ☐ No

39 **How many units of fruit or vegetables do you eat on average per day?** (units means for example a fruit, a cup of juice, potatoes, vegetables)

Number of units ☐☐

40 **How many times a week do you eat warm dinner?**

Number ☐☐

41 **How often do you usually eat these food products?** (Tick once for each line)

	0-1 times/ mth	2-3 times/ mth	1-3 times/ week	4-6 times/ week	1-2 times/ day
Potatoes	☐	☐	☐	☐	☐
Pasta/rice	☐	☐	☐	☐	☐
Meat *(not processed)*	☐	☐	☐	☐	☐
Processed meat *(sausages/meatloaf/meatballs)*	☐	☐	☐	☐	☐
Fruits, vegetables, berries	☐	☐	☐	☐	☐
Lean fish	☐	☐	☐	☐	☐
Fatty fish *(e.g. salmon, trout, mackerel, herring, halibut, redfish)*	☐	☐	☐	☐	☐

42 **How much do you usually drink the following?** (Tick once for each line)

	Rarely/ never	1-6 glasses /week	1 glass /day	2-3 glasses /day	4 or more glasses /day
Milk, curdled milk, yoghurt	☐	☐	☐	☐	☐
Juice	☐	☐	☐	☐	☐
Soft drinks with sugar	☐	☐	☐	☐	☐

43 **How many cups of coffee and tea do you drink daily?** (Put 0 for the types you do not drink daily)

	Number of cups
Filtered coffee	☐☐
Boiled coffee (coarsely ground coffee for brewing)	☐☐
Other types of coffee	☐☐
Tea	☐☐

44 **How often do you usually eat cod liver and roe?** (i.e. "mølje")

☐ Rarely/never ☐ 1-3 times/year ☐ 4-6 times/year

☐ 7-12 times/year ☐ More than 12 times/year

45 **Do you use the following supplements?**

	Daily	Sometimes	No
Cod liver oil or fish oil capsules	☐	☐	☐
Omega 3 capsules *(fish oil, seal oil)*	☐	☐	☐
Vitamins and/or mineral supplements	☐	☐	☐

QUESTIONS FOR WOMEN

46 **Are you pregnant at the moment?**

☐ Yes ☐ No ☐ Uncertain

47 **How many children have you given birth to?**

Number ☐☐

48 **If you have given birth, fill in for each child: birth year, birth weight and months of breastfeeding** (Fill in the best you can)

Child	Birth year	Birth weight in grams	Months of breastfeeding
1	☐☐☐☐	☐☐☐☐	☐☐
2	☐☐☐☐	☐☐☐☐	☐☐
3	☐☐☐☐	☐☐☐☐	☐☐
4	☐☐☐☐	☐☐☐☐	☐☐
5	☐☐☐☐	☐☐☐☐	☐☐
6	☐☐☐☐	☐☐☐☐	☐☐

49 **Have you during pregnancy had high blood pressure?**

☐ Yes ☐ No

50 **If yes, during which pregnancy?**

☐ The first ☐ Second or later

51 **Have you during pregnancy had proteinuria?**

☐ Yes ☐ No

52 **If yes, during which pregnancy?**

☐ The first ☐ Second or later

53 **Were any of your children delivered prematurely (a month or more before the due date) because of preeclampsia?**

☐ Yes ☐ No

54 **If yes, which child?**

1st child ☐ 2nd child ☐ 3rd child ☐ 4th child ☐ 5th child ☐ 6th child ☐

55 **How old were you when you started menstruating?**

Age ☐☐

56 **Do you currently use any prescribed drug influencing the menstruation?**

Oral contraceptives, hormonal intrautrine or similar ☐ Yes ☐ No

Hormone treatment for menopausal problems ☐ Yes ☐ No

When attending the survey centre you will get a questionnaire about menstruation and possible use of hormones. Write down on a paper the names of all the hormones you have used and bring the paper with you. You will also be asked whether your menstruation have ceased and possibly when and why.

Appendix F

Fracture registration protocol

Fracture registration protocol

by Luai A. Ahmed, UiT

Note: The registration process describes a registry in 2002 that covers the period 1994-2000. There has been two follow-up fracture registries since, in 2005 (covers 2001-2004) and in 2010 (covers 2005-2009). The newer registers (2001-2005 and 2005-2010) were performed using very similar protocols.

Fracture registration *(protocol)*

Information from the radiographic descriptions was registered in a Microsoft Access file.

Description of the variables used in the fracture registration process (2002):

Akt. Rekv.nr.: The referral number in the archive of the department of radiology.

Navn: The name of the patient.

Usdag: The date of examination.

Side: The side of the examination, right (Dex) or left (Sin).

Brudd side: The side of the fracture, Dex or Sin.

If it wasn't match with the fracture site in the X-ray report, that will be mentioned in the comment bar.

Lokal: Code for the location of the fracture. See codes below.

-albue
-Ankel
-ansikt
-bekken
-cervicalcol.
-clavikula
-finger
-fotrot
-Håndledd
-håndrot
-hofte
-kne
-lårskaft
-legg
-lumbalcol.
-nese
-overarm
-ribben
-scapula
-skulder
-sternum
-tær
-thorocalcol.
-underarm

Utvkl : Code for the x-ray picture purpose. See codes description below.

Forbedring:
Forverring:
Gamle forandringer: Old changes.
Kontroll: Control picture.
Mistenkt:
Opr. Innlagt rtg. Tett mat.:
Postop. Forandringer:
Progresjon: Progression.
Regresjon: Regression.
Repoert:
Sekvele:

Brudd etter 94: If the fracture occurred after 1994 (ja/ yes) or before 1994 (nei/ no).

All fractures examined in 1994-95 with uncertain dates of fracture were reported as (Nei); not after 1994.

Sikkert Brudd:

Ja: the fracture was confirmed in the X-ray report.

Nei: No fracture in the X-ray report. The fracture was not certain, not confirmed in the X-ray report or been described as suspected, probable or possible fracture.

Brudd #: The number of fractures for the same person by the day of examination.

- Fractures of more than one bone at the same site or location (description of locations below) were counted as one fracture, for example Tib/Fib or Ulna/Rad.
- Refracture or a new fracture at the same site was counted as a new fracture when it occurred after the first one (not at the same day).
- If more than one fracture happened at the same time at different sites, for example in a car accident, the number of fractures at the time of examination was counted as the total number of fractures.

- If there was a fracture, which mentioned only in the X-ray report, it will be counted in the total number of fractures and its site will be stated in the comment bar.
- Vertebral compression fractures were counted as one fracture if they were at the same vertebral segment (ex. Lumber vertebrae). Each involved vertebra was mentioned in the comment bar.
- If a new vertebra within the same vertebral segment developed compression for the first time, it was counted as a new fracture in addition to the old compression counted before.
- Increase in the compression of one or more vertebrae wasn't counted as a new fracture.
- (21-03-02) start mentioning which bones were involved in finger, toe, hand root, foot root, carpal, tarsal and rib bones in the comment bar.

For finger and toe, we reported which digit and phalange were fractured

(ex. 1st, 3rd phal. = first digit, distal phalange).

For hand root, foot root, carpal, tarsal and rib, we reported the number of bones fractured.

Brudd lok. Describes the location of the fracture as one of the following sites:

Albu fx flere: Fracture of the elbow: involvement of more than two bones around the elbow.

Annet*: any other fracture not mentioned in the list below.

Ansikts fx : Fracture of the face: fracture of any bone of the face bones.

Bekken fx.: Fractures of the pelvis.

Cervicalcol : Fracture of the cervical vertebrae: wedge compression fracture of the vertebral body, fracture of the atlas, fracture of the dens of the axis and fracture of a spinous process.

Clavicula fx : Fracture of the clavicle.

Coccyx fx : Fracture of the coccyx.

Femur dist : Fracture of the distal part of the femur: supracondylar fracture or fracture of the femoral condyles.

Femur skaft : Fracture of the shaft of the femur.

Femur trock : Fracture of the femoral trochanteric region: any fracture that lies approximately between the greater and the lesser trochanter.

Femurcollum : Fracture of the neck of the femur.

Fibula dist.: Fracture of the distal part of the fibula, isolated fracture of the lateral malleolus.

Fibula prox.: Fracture of the proximal part of the fibula.

Fibula skaft : Fracture of the shaft of the fibula

Finger fx.: Fracture of the phalanges of the fingers.

Håndrots fx.: Fracture of the carpal bones.

Humerus dist : Fracture of the distal part of the humerus: fracture of the epicondyle, the condyle or supracondylar fracture.

Humerus prox.: Fracture of the proximal part of the humerus: fracture of the neck or fracture of the greater tuberosity.

Humerus skaft : Fracture of the shaft of the humerus.

Kne fx flere : Fracture about the knee involving more than one bone, the femoral condyles, the patella or the tibial condyles.

Lumbalcol.: Fracture of the lumbar vertebrae: wedge fracture compression of the vertebral body

Metacarp. fx.: Fracture of the metacarpal bones.

Metatars. fx.: Fracture of the metatarsal bones.

Radius dist.: Fracture of the distal part of the radius: fracture of the lower end of the radius (Colles's fracture).

Radius prox.: Fracture of the proximal part of the radius: the head of the radius.

Radius skaft : Fracture of the shaft of the radius.

Ribben : Fracture of the ribs

Sacrum fx.: Fracture of the sacrum.

Skulderblad fx.: Fracture of the scapula.

Sternum : Fracture of the sternum.

Tå fx.: Fracture of the phalanges of the toes.

Thoracalcol. : Fracture of the thoracic vertebrae: wedge fracture compression of the vertebral body.

Tib/Fib skaft : Fracture of the shafts of the tibia and fibula.

Tibia dist : Fracture of the distal part of the tibia, isolated fracture of the medial malleolus.

Tibia prox.: Fracture of the proximal part of the tibia, the condyles of the tibia.

Tibia skaft : Fracture of the shaft of the tibia.

Ulna dist.: Fracture of the distal part of the ulna.

Ulna prox : Fracture of the proximal part of the ulna: fracture of the olecranon process, the coronoid process and the upper most third of ulna.

Ulna skaft : Fracture of the shaft of the ulna.

Ulna/Radius skaft : Fracture of the shafts of the forearm bones: both ulna and radius.

* Patella fractures were reported as (Annet); others, and explained in the comment bar.

Energi: Description of the energy (the causative injury) when the fracture has occurred.

Usikker: No description for the energy in the medical report: fall.

Lav: law-energy fracture, the causative injury was slight: stumble, slip. At the level of the ground, the standing height, with no additional force.

Hoy: high-energy fracture, the causative injury was strong: traffic accident, fall from the stairs or any level above the ground level.

Patologi: the cause of fracture was a pathological disease in the bone, metastasis.

Sportsulykke: the fracture happened while practicing any kind of sport.

Snø/is: Involvement of snow or ice in the fracture mechanism.

Ukjent: there was no mention of the fracture mechanism or there was snow or ice in it.

Ja: snow or ice was mentioned in the medical report in the description of the fracture; slippery surface, slid on ice, skiing, skating, shuffling snow, etc.

Nei: the medical report described the mechanism of fracture inside the house (bedroom, kitchen, bathroom, etc), on the floor, on the street.

ISBN xxx-xx-xxxx-xxx-x