Hilde Lohne-Seiler

Physical activity level, musculoskeletal fitness,balance, strength and power performance in older adults

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SAMMENDRAG

Introduksjon: Forbindelsen mellom fysisk aktivitet og forebygging av sykdom, opprettholdelse av uavhengighet, og økt livskvalitet hos eldre er godt dokumentert. Det er imidlertid mangel på populasjonsbaserte data hvor fysisk aktivitetsnivå er registrert med objektive målemetoder i assosiasjon med selv-rapportert helse, muskelskjelett form og balanse hos eldre menn og kvinner. I tillegg er det begrenset kunnskap knyttet til effekt av power trening tilrettelagt for eldre i forhold til funksjonell adaptiv treningsrespons. Det er derfor behov for å utvikle adekvate målemetoder og verktøy, samt undersøke ulike treningsregimer rettet mot muskelstyrke, muskelpower, og funksjon hos eldre individer.

Formål: Formålene med denne avhandlingen var derfor: 1) å beskrive akselerometer-bestemt fysisk aktivitetsnivå, samt å undersøke assosiasjonen til selv-rapportert helse i en populasjon av norske eldre individer (65-85 år) (**Artikkel I**), 2) å beskrive muskelskjelett form og balanseevne hos norske eldre menn og kvinner, samt undersøke assosiasjonen med objektivt-målt fysisk aktivitets nivå, uttrykt som en økning på 1.000 skritt per dag (**Artikkel II**), 3) å undersøke om den felt-baserte «30-s chair stand test» og den modifiserte felt-baserte versjonen av «progressive isoinertial lifting evaluation (PILE) test» var valide tester for å kunne anslå sammenhengen mellom underekstremitetsstyrke og power og total løftestyrke og power hos eldre individer, og i tillegg undersøke reliabilitet på tvers av testforsøk for de laboratorie-baserte testene («chair-stand» og «box-lift» testene) og reliabilitet på tvers av testdager for de felt- og laboratorie-baserte testene (**Artikkel III**), 4), å undersøke effekten av tradisjonell versus funksjonell styrketrening, på muskelstyrke og muskelpower målt både funksjonelt og tradisjonelt hos eldre individer sammenlignet med kontroller (**Artikkel IV**).

Deltakere og metoder: Avhandlingen er basert på tre separate studier. **Artikkel I** og **Artikkel II** er basert på en nasjonal tverrsnitts-multisenterstudie av norske eldre individer (65-85 år), hvor man undersøkte objektivt målt fysisk aktivitetsnivå ved hjelp av ActiGraph GT1M akselerometer og selv-rapportert helse ved bruk av spørreskjema (testfase I: 282 kvinner i alderen 71.8 (SD: 5.6) år og 278 menn i alderen 71.7 (5.2) år). I tillegg ble også objektivt målt muskelskjelett form og

balanse målt ved hjelp av følgende tester: «handgrip strength test», «static back extension test», «sit and reach test», «back scratch test», og «one leg standig test» (testfase II: 85 kvinner i alderen 73.2 (5.4) år og 76 menn i alderen 72.3 (4.8) år). **Artikkel III** er basert på en reliabilitets- og valideringsstudie av felt- og laboratoriebaserte funksjonelle styrketester, hvor 19 eldre individer i alderen 72.4 (5.0) år ble inkludert. **Artikkel IV** er basert på en intervensjonsstudie, som undersøkte effekten av styrketrening i maskiner versus funksjonell styrketrening hvor «force platform» og «linear encoder» ble brukt til å registrere muskelstyrke og muskelpower. Seksitre deltakere (69.9 (4.1) år) ble randomisert til en tradisjonell styrkegruppe (trening i maskiner) (n=23) og en funksjonell styrkegruppe (n=30), eller til en ikke-randomisert kontrollgruppe (n=10). Treningsperioden varte i 11 uker med en treningsdose tilsvarende 2 ganger/uke, og med 3 serier x 8 repetisjoner.

Hoved resultat: Hoved resultatet fra **Artikkel I** viste at totalt fysisk aktivitets nivå (tellinger per minutt) var forskjellig mellom aldersgruppene, hvor de eldste (80-85 år) hadde et 50% lavere aktivitets nivå sammenlignet med de yngste (65-69 år). Ingen kjønnsforskjeller ble observert i totalt fysisk aktivitetsnivå innenfor hver aldersgruppe (65-69, 70-74, 75-79, og 80-85 år). Fysisk aktivitet var forskjellig på tvers av de ulike nivåer av selv-rapportert helse. 51% høyere totalt fysisk aktivitetsnivå ble registrert hos eldre som rapporterte «veldig god helse» sammenlignet med dem som rapporterte «dårlig/veldig dårlig helse». **Artikkel II** viste at de yngste individer (65-69 år) hadde bedre statisk balanse og utholdende muskelstyrke i kroppsstammens ekstensorer sammenlignet med eldre individer. Eldre kvinner (65-85 år) hadde bedre leddbevegelighet i over- og under ekstremitet og bedre utholdende muskelstyrke i kroppsstammens ekstensorer sammenlignet med eldre menn (65-85 år), hvorpå eldre menn (65-85 år) hadde bedre gripestyrke sammenlignet med eldre kvinner (65-85 år). Ingen kjønnsforskjeller ble observert i statisk balanse. Et høyere fysisk aktivitetsnivå, var assosiert med bedre statisk balanse og utholdende muskelstyrke i kroppsstammens ekstensorer hos eldre individer (65-85 år). **Artikkel III** viste at intradag reliabilitet av de laboratorie-baserte testene «chair-stand» og «box-lift» testene var høy, og interdag reliabilitet av både de felt- og laboratorie-baserte versjoner av disse testene var akseptable.

Intra-klasse korrelasjon mellom prestasjonene i de felt- og laboratorie-baserte versjonene av «chair-stand» og «box-lift» testene var lav. **Artikkel IV** viste at ingen forskjell i effekt ble registrert mellom tradisjonell styrketrening i maskiner og funksjonell styrketrening på funksjonell power («chair-stand-« og «box-lift power») og tradisjonell maksimal styrke («leg-press-« og «bench-press maximal strength») hos eldre individer. Gruppen som trente tradisjonell styrketrening økte tradisjonell overkroppspower («bench-press power») sammenlignet med både gruppen som trente funksjonelt og kontroller.

Konklusjon: I et nasjonalt utvalg av eldre individer hvor objektive målinger av fysisk aktivitetsnivå, muskelskjelett form og balanse ble brukt, viste at fysisk aktivitetsnivå, statisk balanse og utholdende muskelstyrke (kroppsstammens ekstensorer) var forskjellig mellom ulike aldersgrupper. Totalt fysisk aktivitetsnivå var assosiert med selv-rapportert helse, og høyere fysisk aktivitetsnivå var assosiert med bedre statisk balanse og utholdende muskelstyrke (kroppsstammens ekstensorer) hos norske eldre individer. Våre funn indikerer en relativ høy intra- og interdag reliabilitet av de feltbaserte «chair-stand» og «box-lift» testene, men de er trolig ikke valide til å kunne vurdere forholdet mellom muskelstyrke- og power hos eldre individer. Med unntak av «bench-press power», ble ingen forskjeller i effekt av treningsintervensjonene (tradisjonell- versus funksjonell styrketrening) funnet på funksjonell power og maksimal kroppsstyrke hos eldre individer.

Nøkkel ord: Fysisk aktivitetsnivå, akselerometer, selv-rapportert helse, form score, funksjonelle styrketester, muskelpower, vekttrening, høy hastighet, kraft, eldre.

SUMMARY

Introduction: The link between physical activity and prevention of disease, maintenance of independence, and improved quality of life in older adults is supported by strong evidence. However, there is a lack of data on population levels where physical activity level has been measured objectively in association with self-reported health, musculoskeletal fitness and balance variables in older men and women. Also, little is known about the functional adaptive responses of older adults to power training. Therefore, there is a need of developing adequate assessment tools/tests and investigating different training regimes aiming at muscle strength, power, and function in older age groups.

Aims: The aims of the thesis were therefore: 1) to describe the level of accelerometer-determined physical activity and to investigate its association to self-reported health in a population of Norwegian older adults (65-85 years) (**Paper I**), 2) to describe musculoskeletal fitness and balance in Norwegian older men and women and to investigate its association with objectively-assessed physical activity levels, expressed as a daily increments of 1,000 steps (**Paper II**), 3) to test if the field-based 30-s chair-stand test and a modified field-based version of the progressive isoinertial lifting evaluation (PILE) test were valid tests for assessing relationships between lower extremity strength and power and total lifting strength and power in older adults, and also to investigate the reliability across trials for the laboratory-based tests («chair-stand» and «box-lift» tests) and the reliability across days for the field- and laboratory-based tests (**Paper III**), and 4) to test the effect of traditional versus functional strength training, both performed at 80% of 1RM at a maximal intended concentric velocity, on muscle strength and power measured functionally and traditionally in older adults compared to non-training controls (**Paper IV**).

Participants and methods: The thesis is based on three separate studies. **Paper I** and **Paper II** are based on a national cross-sectional multicenter study including Norwegian older adults (65-85 years) investigating objectively measured physical activity level using the ActiGraph GT1M accelerometer and self-reported health using a questionnaire (test phase I: 282 women, aged 71.8 (SD: 5.6) years and 278 men aged 71.7 (5.2) years), in addition to objectively measured musculoskeletal fitness and balance using handgrip strength-, static back extension-, sit and reach-, back scratch-, and one leg standing tests (test phase II: 85 women aged 73.2 (5.4) years and 76 men aged 72.3 (4.8) years). **Paper III** is based on a reliability- and validity study of field- and laboratory based functional strength tests including 19 older adults aged 72.4 (5.0) years, while **Paper IV** is based on an intervention study investigating strength training in machines versus functional strength training using a force platform and linear encoder to measure muscle strength- and power. Sixty-three participants (69.9 (4.1) years) were randomized to a traditional strength group (training with machines) (n=23) and a functional strength group (n=30), or to a non-randomized control group (n=10). The training dose was 2 times/week, 3 sets x 8 repetitions, for 11 weeks.

Main results: The main results from **Paper I** showed that overall physical activity level (counts per minute) differed between the age groups where the oldest (80-85 years) displayed a 50% lower activity level compared with the youngest (65-69 years). No sex differences were observed in overall physical activity within each age group (65-69, 70-74, 75-79, and 80-85 years). Physical activity differed across levels of self-reported health, and a 51%higher overall physical activity level was registered in those with “very good health” compared to those with “poor/very poor health”. **Paper II** showed that the youngest (65-69 years) had better static balance and muscular endurance in trunk extensors, compared with the older ones. Older women (65-85 years) had better upper and lower body joint flexibility and muscular endurance in trunk extensors than older men (65-85 years), whereas older men (65-85 years) had better handgrip strength than older women (65-85 years). No sex differences in static balance were observed. A higher physical activity level was associated with better static balance and muscular endurance in trunk extensors in older adults (65-85 years). **Paper III** showed that the intraday reliability of the laboratory-based chair-stand and box-lift tests was high, and the interday reliability of both field- and laboratory-based versions of these tests was acceptable. Intra-class correlations between performances in the field- and laboratory versions of chair-stand- and box-lift tests were low. **Paper IV** showed that no difference in the effects were revealed between traditional strength training with machines and functional strength training on functional power (chair-stand- and box-lift power) and traditional maximal strength (leg-press- and bench-press maximal strength) in older adults. The traditional strength training group improved traditional upper body power (bench-press power) compared with both functional strength training group and nontraining-controls.

Conclusions: In a national sample of older adults using objective assessments of physical activity level and musculoskeletal fitness- and balance capacity revealed that physical activity level, static balance and muscular endurance (trunk extensors) differed by age. Overall physical activity levels were associated with self-reported health, and a higher physical activity level was associated with better static balance and muscular endurance in trunk extensors in the Norwegian older adults. Our findings indicate a relatively high intra- and interday reliability of the field-based chair-stand and box-lift tests, but they may not be valid for assessing relationships between muscle strength and power in older adults. Except for bench-press power there were no differences in the effect of the training interventions (traditional versus functional strength training) on functional power and maximal body strength in older adults.

Key words: Physical activity level, accelerometers, self-reported health, fitness score, functional strength tests, muscular power, weight training, high velocity, force, elderly.

LIST OF PAPERS

This thesis is based on the following papers, referred to in the text by their Roman numerals:

I. Lohne-Seiler H, Hansen BH, Kolle E, Anderssen SA. Accelerometer- determined physical activity and self-reported health in a population of older adults (65-85 years): a cross-sectional study. *BMC Public Health*. 2014; 14:284-294.

II. Lohne-Seiler H, Kolle E, Anderssen SA, Hansen BH. Musculoskeletal fitness and balance in older men and women (65-85 years) and its association with steps per day: a cross sectional study. Re submitted to *BMC Geriatrics*.

III. Lohne-Seiler H, Anderssen SA, Blazevich A, Torstveit MK. Reliability and validity of chair-stand and box-lift tests in elderly individuals. Submitted to *PLOS ONE*.

IV. Lohne-Seiler H, Torstveit MK, Anderssen SA.
Traditional versus functional strength training: Effects on muscle strength and power in the elderly. *Journal of Aging and Physical Activity*. 2013; 21:51-70.

ABBREVATIONS

BMI:	Body mass index
CG:	Control group
CI:	Confidence interval
CS_{field}:	Field-based version of the chair-stand test
CS_{lab}:	Laboratory-based version of the chair-stand test
FSG:	Functional strength group
HPSG:	High power strength group
ICCs:	Intra-class correlations
M:	Mean
MVPA:	Moderate to vigorous physical activity
N:	Newton
PA:	Physical activity

$\text{PILE}_{\text{field}}$: Field-based version of the box-lift test

PILE_{lab}: Laboratory-based version of the box-lift test

1RM: Maximal weight an individual can lift one time

SD: Standard deviation

SEM: Standard error of the mean

STP: Steps per day

W: Watt

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DEFINITIONS AND BASIC PRINCIPLES

Physical activity is a complex human behavior that includes all bodily movements, and is defined as any bodily movement produced by skeletal muscles that result in energy expenditure [1]. The Metabolic Equivalents of Task (METs) is a physiological measure expressing the energy cost of physical activities and is calculated as the ratio of the metabolic rate for an activity divided by the resting metabolic rate. One MET is defined as 1 kcal/kg/hour, equivalent to 3.5 ml/kg/min and is roughly equivalent to the energy cost of sitting quietly [2]. General physical activities are defined by level of intensity, whereas light-intensity activities are defined as 1.1 to 2.9 METs, moderate-intensity activities as 3.0 to 5.9 METs (equivalent to 3.5 – 7 kcal/minute), and vigorous-intensity activities are defined as 6.0 METs or more (equivalent to more than 7 kcal/minute) [3]. In addition to intensity, physical activity also varies along four other dimensions: duration, frequency, modes which is the type of activity carried out (e.g. walking, running, carrying loads, or bicycling) and the context or reason for physical activity (e.g. transportation, household, or exercise) [4].

Physical training, also referred to as exercise, is physical activity that is planned, structured, and repetitive done to improve or maintain one or more components of physical fitness [1].

Physical fitness is a set of attributes that people have or achieve that relates to the ability to perform physical activity where the individual effort is crucial for the outcome [1]. These attributes are categorized into; 1) health-related fitness (e.g. cardiorespiratory endurance, muscular endurance, muscular strength, and flexibility) and 2) skill-related fitness (e.g. agility, balance, coordination, speed, power, and reaction time) [1].

Physical function is defined as the ability to carry out various activities that require physical capability, ranging from self-care activities (basic activities of daily living (ADL)) to more vigorous activities that require increasing degrees of mobility, strength, or endurance [5]. Functional status is the degree to which physical conditions (i.e. the number of health problems experienced by an individual) prevent persons from being able to execute ADLs, instrumental activities of daily living (IADLs, i.e. preparing meals, doing household, and having the mobility to go outside the house), and discretionary activities (e.g. hobbies, recreation, and social contacts) [6].

Older adults (also referred to as elderly) are defined as individuals in the following age groups: the “young-old” (65-74 years of age) and the “old” (75-85 years of age) [6].

Musculoskeletal fitness consists of three components; muscular endurance, muscular strength and joint flexibility [7]. Muscular strength (dynamic) is defined as the maximum force a muscle or muscle group can generate at a specific velocity. Muscular endurance is the ability of a muscle or muscle group to perform repeated contractions against a load for an extended period of time. Flexibility (static) is the range of motion of the joint [7].

Balance is defined as the ability to maintain the equilibrium while stationary or moving [8].

Strength performance is defined as the accomplishment of a given task measured as the ability to produce maximum force [7]. The unit of measurement is newton.

Power performance is defined as the accomplishment of a given task measured as the ability to produce force rapidly (equivalent to the product of the force developed and speed of the contraction) [9]. The unit of measurement is watt.

1. INTRODUCTION

This introduction provides a short overview of physical activity level, self-reported health, musculoskeletal fitness and balance in older adults, with assessments and status integrated. Finally, muscle strength and power in older adults are outlined with a special focus on age-related changes and function, assessments and the effects of different strength-training regimes.

1.1 Physical activity in older adults

In Europe, there is a growing population of older adults, and it is predicted that the current 15% of the total population aged 65 years and older will increase to more than 25% by 2050 [10]. A similar trend is also predicted in America [11] and Australia [12]. As this is the fastest-growing age group of the population, it becomes increasingly apparent that investments in older adults and their health are essential. Regular physical activity in older adults is critically important for healthy aging [13]. The link between regular physical activity and disease prevention, maintenance of independence and improved health and quality of life is supported by strong evidence [14–16], and it is therefore of great importance to maintain regular physical activity levels as long as possible.

1.1.1 Assessment of physical activity

Methods of assessing physical activity can be categorized into 1) self-reporting (e.g., questionnaires, diaries and logs) and 2) objective measures (motion sensors such as accelerometers and pedometers, heart rate monitoring, direct observation and doubly labeled water) [17]. National surveillance systems to monitor physical activity have historically included subjective assessment tools such as self-reported questionnaires because of their low cost, which makes them appropriate for large population studies. In addition, subjective measures often provide detailed information regarding the specific type of activity [18]. However, subjective methods have a limited ability to accurately record activities, especially those that are unstructured and of light to moderate intensity [19]. Because of the limitations of self-reporting methods, interest in objective measurements of physical activity has increased in recent decades [20; 21]. Objective measurements are able to record physical activity across all intensities and are not subject to the bias of self-reporting. In older adults, total physical activity levels seem to have a greater influence on health outcomes compared with moderate-to-vigorous physical activity (MVPA, with moderate activity defined as 3.0–5.9 metabolic equivalents (METs) and vigorous activity as ≥6.0 METs) alone [22; 23]. Based on this perspective, it is important to be able to measure total physical activity level, including unstructured and light activities, in the older population.

Accelerometers are currently viewed as the minimum standard for physical activity assessment in epidemiological research [24] and can be used to estimate the time spent in light-, moderate- and high-intensity physical activity [25]. As part of public health promotion, the goal is to increase physical activity levels among older adults. According to both global [26] and national [27] strategy plans on physical activity, there is a need to monitor physical activity on a nationwide level using consistent, reliable and valid measurement tools. Furthermore, this screening could prove helpful for obtaining a better understanding of the elderly's participation in physical activity, thereby helping to guide the development of the necessary physical activity interventions targeting older adults.

1.1.2 Physical activity recommendations

In 1995, the physical activity recommendations for health were published by the American College of Sports Medicine (ACSM) and the Centers for Disease Control and Prevention. It was established that all adults should exercise for 30 minutes on at least five, but preferably all, days of the week at a moderate-intensity level, being defined as any activity with an energy cost of 3–6 METs [28].

In 1998, the ACSM's Position Stand "Exercise and Physical Activity for Older Adults" was presented, emphasizing that participation in regular physical activity (both endurance and strength training) leads to a number of favorable responses that contribute to healthy aging [29]. Endurance training can maintain and improve various aspects of cardiovascular function, enhance submaximal performance, reduce risk factors associated with disease states (e.g., heart disease, diabetes), improve health status and contribute to an increase in life expectancy [30].

Strength training in combination with balance training can help offset the age-related loss in muscle mass and strength, improve bone health and postural sway, thereby reducing the risks of osteoporosis and falling, and can increase flexibility and range of motion [30].

In 2004, the Nordic physical activity recommendations were presented by the Nordic Council on Nutrition and Physical Activity and stated as follows.

> *"For all inactive adults and older adults, daily physical activity of moderate and/or vigorous intensity corresponding to an energy expenditure of about 150 kcal yields substantial health benefits. This energy expenditure is equivalent to brisk walking for about 30 minutes, and the activity can probably be divided into shorter intervals of physical activity during the course of the day, for instance intervals lasting 10 minutes"* [31].

In 2014, the recommendations were again updated as follows.

> *"1) The elderly should engage in at least 150 minutes of moderate-intensity physical activity throughout the week or at least 75 minutes of vigorous-intensity physical activity throughout the week, or engage in an equivalent combination of moderate- and vigorous-intensity activity preferably spread out over most days during the week. 2) Physical activity should be performed in bouts of at least 10 minutes. 3) For additional health benefits, the elderly should increase their moderate-intensity physical activity to 300 minutes per week or engage in 150 minutes of vigorous-intensity physical activity per week, or engage in an equivalent combination of moderate- and vigorous-intensity activity. 4) Adults of this age group with poor mobility should perform balance exercises to enhance balance and prevent falls, on 3 or more days per week. 5) Muscle-strengthening activities should be performed involving major muscle groups on 2 or more days per week. 6) Sedentary behavior should be reduced"* [32].

Regular physical activity in the elderly is associated with improved strength and functional ability [33], is inversely related to mortality [34] and has been found to be strongly associated with maintaining mobility [35]. Balance and muscle-strengthening activities appear to influence risk factors for falls by increasing muscle strength (lower limb) and balance ability [36; 37], which is of great importance in maintaining the independence of older adults in daily life for longer [36]. Furthermore, a relationship between sedentary behavior and obesity has been demonstrated [38; 39], as well as a dose-response relationship between TV viewing and cardiovascular mortality and total mortality [40]. The importance of performing regular physical activity incorporating balance and muscle-strengthening activities in addition to reducing the amount of time spent sitting (i.e., sedentary behavior) have therefore been emphasized in the 2014 recommendations for older adults. However, there is a lack of information related to these data on a population-based level.

1.1.3 Status of accelerometer-determined physical activity

There are only a limited number of population-based studies where physical activity levels have been measured objectively in older adults. Most of these studies were carried out in the United States of America (USA) [18; 21; 41], Canada [42] and the United Kingdom (UK) [43; 44], and relatively few studies have been undertaken in Northern European countries [45-47] (Table 1). Accelerometer-determined physical activity levels differ significantly between different age groups, with the oldest age group having substantially lower mean physical activity levels (measured in counts per minute (cpm)) than the youngest age group [18; 21; 41; 43-46]. These studies have also shown a significantly higher mean physical activity level (based on cpm) among older men compared with older women [18; 41-45]. A study conducted in Iceland [45] found that older adults spent a large proportion of their day being sedentary (75%), defined as 0-99 cpm, followed by low light-intensity physical activity (21%), defined as 100–759 cpm. These findings are comparable with those reported among older adults in the UK [43] and Canada [42].

When looking at sex- and age-related differences in intensity-specific categories, older men in the UK performed significantly more minutes of MVPA (defined as ≥1,952 cpm) per day than women (23.1 versus 13.8 min) [43]. Older women in Iceland spent more time in low light-intensity physical activity but less time in sedentary physical activity and MVPA compared with older men [45]. Furthermore, older adults in the UK had a steep decline in the proportion of active time spent in MVPA with increasing age [43]. Similar patterns were also observed among older adults in the USA [41] and among Canadians aged 20–79 years [42], where MVPA decreased with increasing age. Furthermore, when looking at sex- and age-related differences regarding steps per day, Davis et al. [43] found that younger participants (70–75 years) averaged significantly more steps per day (5,661) than participants aged over 80 years (3,410). Harries et al. [44] also showed that step count declined steadily with age among older adults, and men achieved 754 more steps per day than did women. Table 1 provides an overview of studies reporting accelerometer-determined physical activity levels in older men and women.

Table 1. Accelerometer-determined physical activity (PA) level in older men (M) and women (W).

	Subjects		Overall PA (cpm[1], spd[2])	PA intensity level (sedentary, low-light, MVPA[3])	Type of accelerometer
Authors (country)	**Age (yr)**	**Sex (N)**			
Troiano et al., 2008 (USA) [21]	60-69	W (287)	251.2 cpm	12.4 h/day spending at MVPA	Actigraph LLC
	70+	W (349)	169.8 cpm	5.4 h/day spending at MVPA	
	60-69	M (269)	256.7 cpm	16.7 h/day spending at MVPA	
	70+	M (355)	188.9 cpm	8.7 h/day spending at MVPA	
			PA declined across age M more active than W	(MVPA = 2,020-5,999 cpm)	
Harris et al., 2009 (UK) [44]	65+	W (114) M (124)	Average spd = 6,443 Spd declined steadily with age M achieved 754 spd more than W		Actigraph GT1M
Hawkins et al., 2009 (USA) [18]	18-60+ (white ethnic group)	W (713) M (714)	PA decreased with increasing age M more active than W		Actigraph AM

Davis et al., 2011 (UK) [43]	78.6(SD[4]:5.7) 77.7(SD[4]:5.8)	W (113) M (117)	Younger (70–75 yr) more active (5,661 spd) than older (80+ yr) (3,410 spd)	M spent more time in MVPA (≥1,952 cpm) than W (23.1 vs 13.8 min MVPA per day)	Actipraph GT1M
Evenson et al., 2012 (USA) [41]	60+	W (1,314) M (1,316)	Average cpm = 216	Mean MVPA (2,000 cpm) = 10.8 min/day MVPA lower with each successive age group (60-69, 70-79, and ≥80) MVPA higher among M than W Average time spent in sedentary behavior (<100 cpm) = 8.5 h/day Amount of sedentary time greater among participants aged 80+ than in younger age groups Amount of sedentary time greater among M compared to W	Actigraph LLC
Arnardottir et al., 2013 (Island) [45]	80.2 (SD[4]:5.1) 79.7 (SD[4]:4.2)	W (358) M (221)	M had slightly higher average total PA (counts × day^{-1}) than W	75% of total wear time was sedentary time (0-99 cpm), 21% at low-light PA (100-759 cpm), and 1% at MVPA (≥2,020 cpm) W spent more time in low-light PA than M W spent less time in MVPA than M	Actigraph GT3X

[1] *counts per minute,* [2] *steps per day,* [3] *moderate to vigorous physical activity,* [4] *standard deviation*

1.1.4 Self-reported health

The World Health Organization recommends that in addition to national surveillance systems monitoring physical activity, information on how individuals perceive their own health should be collected in population-based studies, including those that assess older adults. Furthermore, international research designed to compare health across countries should also be prioritized to provide new insights [48]. Self-reported health status is assessed by answering a single question about the perception of an individual's own health, with response categories ranging from "very good" to "very poor" [49]. It is considered a sensitive measure of overall health in older adults, influenced by physical function, the presence of disease, the existence of disabilities, functional limitations and by the rate of aging [50]. It is viewed as a holistic measurement of health, reflecting both physical and mental health, as well as well-being [49]. However, few studies [44] have examined physical activity levels measured objectively in the elderly in combination with simple measures of health [51].

1.2 Musculoskeletal fitness and balance in older adults

An individual's ability to perform physical activity relates to a set of attributes, which includes muscular strength, muscular endurance, joint flexibility and balance [52]. Increasing age leads to a progressive loss of all of these physical characteristics [53–55]. Age-related musculoskeletal fitness (a compound picture of upper- and lower-body muscular strength, and upper- and lower-body joint flexibility) and balance loss might be explained by hormonal, metabolic, nutritional and immunological changes [54; 56], qualitative changes in the connective tissue [57; 58], qualitative and quantitative changes in the muscular system [54; 59-61] and degenerative processes in the central and peripheral nervous system [62].

Furthermore, the loss of musculoskeletal fitness and balance in combination with decreased physical activity levels is strongly predictive of falls [63], disability [64], hospitalization [65], reduced quality of life [66] and increased mortality [53; 67] in older individuals. The incidence of falls increases with age, equivalent to a 35–40% increase in falls in people over 60 years of age compared with people less than 60 years of age [68; 69]. Muscle weakness, impaired gait and diminished balance are the most significant risk factors for falling [68; 69]. The management of daily life activities is based on an individual's balance capability, meaning the ability to maintain the body's position over its base of support, whether this base is stationary or moving [69]. Static balance is the ability to control postural sway during standing/stable conditions [6] and might therefore be an important component for predicting [160] and preventing falls and independent living, and through this, successful aging [69].

There is strong evidence showing that enhancement of physical activity results in improved fitness, increased functional ability and health-related quality of life in older adults [70]. An adequate musculoskeletal fitness level and balance ability are therefore critical for older adults' ability to perform basic functional tasks, such as lifting and moving objects or rising from a chair and walking, which is in turn of great importance to performing activities of daily living (ADLs) and maintaining functional independence [14; 71]. Despite this knowledge, few published studies have focused on a set of measurements to obtain a more comprehensive picture of musculoskeletal fitness and balance for older adults within activity levels of given populations [72; 73]. In addition, neither of the two studies cited recorded static balance as part of the overall fitness evaluation in older people. In addition, musculoskeletal fitness level and balance ability and their association with objectively assessed physical activity levels have rarely been investigated in older adults [74; 75]. Objective information on physical activity levels, sedentary behavior and musculoskeletal fitness and balance ability has the potential to increase our understanding of older people's physical activity and fitness status, thereby helping to guide the development of the necessary physical activity interventions targeted at older adults.

1.2.1 Assessments of musculoskeletal fitness and balance

There is limited musculoskeletal fitness and balance data for older men and women within population activity levels where standardized-assessment methods have been used [76–78]. Current knowledge is primarily based on studies that have measured handgrip strength [79–82] or balance [83; 84] separately. Few published studies, as underlined above (see 1.2), have focused on an overall fitness evaluation (i.e., a more comprehensive picture of musculoskeletal fitness and balance) among older adults [72; 73].

1.2.2 Status of musculoskeletal fitness and balance

Based on studies conducted in the USA [76], Spain [72], Portugal [73; 85] and Iran [86], older women appeared to have significantly better joint flexibility compared with older men. Flexibility in the lower back and hamstring musculature, assessed using a chair sit-and-reach test, was reported to be –1.8 cm and 3.3 cm for American men and women (aged 60–94 years, n = 7,183), respectively [76], and among Spanish elderly (60–99 years, n = 6,449) the results were –2.9 cm and 1.4 cm for men and women, respectively [72]. Shoulder joint and arch flexibility, evaluated using the back-scratch test, was reported to be –18 cm and –11 cm for older Spanish men and women, respectively [72]. Table 2 provides an overview of cross-sectional studies of joint flexibility in older men and women.

Studies conducted in Canada [79], Brazil [80; 81], Australia [82] and Spain [72] showed significantly better handgrip strength in older men compared with older women, all assessed using dynamometers (Table 2). Older men and women (≥70 years of age) in Australia had a handgrip strength equivalent to 33 kg and 20 kg (right hand), respectively [82], while for the older (≥70 years of age) men and women in Brazil, the results were 31.8 kg and 17.2 kg (right hand), respectively [81].

Significantly better static balance, assessed using one-leg standing time (shoes on and eyes open), was observed among older (60–80 years) Iranian men (3.8 s) than Iranian women (1.2 s) [86]. American women aged 60–86 years scored 20.4 s on a similar test [83] (Table 2).

The main findings in these studies [72; 73], which focused on a more comprehensive picture of musculoskeletal fitness and balance among older adults, showed that all test results declined with increasing age. Women scored better on the upper- and lower-body flexibility tests, whereas men performed better on all other tests (i.e., upper- and lower-body strength, aerobic endurance and dynamic balance) (Table 2).

Table 2. Musculoskeletal fitness (MSF) and balance measurements in older men (M) and women (W).

	Subjects		MSF- and balance tests	MSF- and balance results
Authors (country)	**Age (yr)**	**Sex (N)**		
Rikli & Jones, 1999 [76] (USA)	60-94	W (5,048) M (2,133)	Chair sit and reach test	W: lower back and hamstring flexibility = 3.3 cm M: lower back and hamstring flexibility = -1.8 cm
Briggs et al., 1989 [83] (USA)	60-86	W (71)	One leg standing test (shoes on, eyes open)	W: static balance = 20.4 s (dominant leg)
Schüssel et al., 2008 [81] (Brazil)	≥ 70	W (172) M (76)	Handgrip strength test (using a dynamometer standing position)	W: handgrip strength = 17.2 kg (right hand) M: handgrip strength = 31.8 kg (right hand)
Massy-Westropp et al., 2011 [82] (Australia)	≥70 (18 – 70+)	W (total 1,312) M (total 1,366) (41.5% < 40 yr)	Handgrip strength test (using a dynamometer in seated position)	W:handgrip strength = 20 kg (dominant hand) M: handgrip strength = 33 kg (dominant hand)
Gusi et al., 2012 [72] (Spain)	60-99	W (5,610) M (839)	Chair sit and reach test	W: lower back and hamstring flexibility = 1.4 cm M: lower back and hamstring flexibility = -2.9 cm
			Back scratch test	W: shoulder joint- and arch flexibility = -11 cm M: shoulder joint- and arch flexibility = -18 cm

			Bimanual handgrip test	W: upper body strength = 40.1 kg
				M: upper body strength = 61.6 kg
			6-min walk test	W: aerobic endurance = 394.9 m
				M: aerobic endurance = 402.1 m
			Timed up-and-go test	W: dynamic balance = 8.6 s
				M: dynamic balance = 8.4 s
Nourollahnajafabadi et al.,	60-88	W (40)	One leg standing test	W: static balance = 1.2 s (dominant leg)
2013[86] (Iran)		M (36)	(shoes on, eyes open)	M: static balance = 3.8 s (dominant leg)
Margues et al., 2014 [73]	65-103	W (3,121)	Chair sit and reach test	W: lower back and hamstring flexibility = -7.1 cm
(Portugal)	(75.0	M (1,591)		M: lower back and hamstring flexibility = -15.6 cm
	SD[1]:7.2)		Back scratch test	W: shoulder joint- and arch flexibility = -15.6 cm
				M: shoulder joint- and arch flexibility = -20.9 cm
			30-sec chair stand test	W: lower body endurance strength = 13.1 rep
				M: lower body endurance strength = 13.8 rep
			Arm-curl test (in 30 sec)	W: upper body endurance strength = 15.6 rep
				M: upper body endurance strength = 16.7 rep
			6-min walk test	W: aerobic endurance = 404.7 m
				M: aerobic endurance = 455.4 m
			8-ft up-and-go test	W: dynamic balance = 9.6 s
				M: dynamic balance = 8.5 s

[1] *standard deviation*

There are a limited number of studies assessing the association between musculoskeletal fitness level, balance ability and objectively assessed physical activity levels in older adults. In addition, some of the existing studies showed an association between musculoskeletal fitness, balance and physical activity level, [75; 85; 87; 88], whereas others did not [69; 74]. It is also somewhat difficult to distinguish which components of musculoskeletal fitness (i.e., muscle strength and endurance, and joint flexibility) might be associated with physical activity level in the studies mentioned above. A study conducted by Aoyagi et al. [74] showed that balance and handgrip strength were both unrelated to daily step counts, whereas lower-extremity function (walking speeds and knee extension torque) was positively related to daily step counts in older adults. A study conducted by de Melo et al. [75] showed that balance and lower-body flexibility were both associated with daily step counts in older adults (mean steps for 3 days: ≥6,500).

The majority of the population-based studies mentioned above have all been conducted outside the Nordic countries. In Norway, population-based musculoskeletal fitness and balance data and their association with objectively assessed physical activity levels of individuals aged 65 years and older have not yet been published.

1.3 Muscle strength and power in older adults

Human aging leads to a progressive loss of muscle strength (the product of mass and acceleration), mostly because of the atrophy of muscle mass and loss of muscle fibers [62]. Age-related reductions in muscle mass are primarily a consequence of losses of alpha motor neurons in the spinal cord and secondary denervation of their muscle fibers (reduction in muscle fiber number and size) [62; 89]. A reduction of muscle fibers is associated with motor unit loss, mainly after 60 years of age [60]. Fast-twitch motor units are the most affected. In addition, qualitative changes in muscle cross-sectional areas have been reported with increasing age, which result in a dramatic loss in the ability to produce force rapidly [90; 91]. Muscle power, defined as the product of force and velocity (power = force × velocity), therefore declines more than muscle strength in older men and women [92]. Muscle power has been shown to be positively associated with the ability to perform ADLs and may be a stronger predictor of functional dependency than muscle strength [93; 94]. A significant correlation has been shown between leg-extensor power and performance measures, such as the ability to rise from a chair, climb stairs and walk quickly [94; 95]. Muscle power is also related to dynamic balance [9] and postural sway [91] and may be a stronger predictor of fall risk than muscle strength [96]. Furthermore, increased muscle power may lead to improvements in functional capacity, fall prevention, dependency and disability later in life [97]. Based on this evidence, developing adequate assessment tools/tests and training regimes aimed at measuring muscle strength, power and function in older age groups may be of importance for researchers and clinicians working with older individuals.

1.3.1 Assessments of muscle strength and power

Field-based, rather than laboratory-based, tests are most often used to measure function in elderly populations when the purpose is to measure muscle strength rather than muscle power [98]. Field-based tests evaluating lower- and upper-body strength often include assessing the number of chair-rise repetitions performed within a specified period of time (e.g., 30-s chair-stand test: Jones et al. [99]) or determining the total number of consecutive repetitions an individual is able to perform (e.g., arm-curl test in the Senior Fitness Test battery: Rikli & Jones [100]). However, it may be speculated that these field-based tests are less valid for the measurement of muscle strength than muscle fatigue resistance, although Jones et al. [99] showed a moderately high correlation ($r = 0.78$ for men and $r = 0.71$ for women) between chair-stand performance and maximum leg-press strength in the elderly. Furthermore, James et al. [101] found a moderate correlation ($r = 0.62$ for men and $r = 0.68$ for women) between the 30-s arm-curl test performance and maximum biceps strength in the elderly.

If the intention is to evaluate the functional capacity (i.e., a person’s ability to perform a work-related series of tasks [102]) among elderly individuals, a greater focus is needed on testing integrated movements involving several muscle groups, rather than using simple tasks measuring isolated muscle groups. Test performances could then be considered more similar to the physical challenges that are required in ADLs; e.g., lifting an object. A field-based test, the progressive isoinertial lifting evaluation (PILE) test, by Mayer et al. [103] consists of two parts: one lift from floor to hip height (lumbar test) and one lift from hip height to above shoulder height (cervical test). The PILE test is therefore considered a useful multijoint functional test [103]. However, two-part lifting tests like the original PILE test [103] could be considered less functional when compared with a lifting test performed in one continuous movement. When objects are lifted from the ground to a high level in a single movement, there is a requirement for a higher degree of integrated muscle recruitment [104], and these muscle recruitment strategies are more similar to many ADLs [92]. A single continuous lifting test could therefore be considered more valid and functionally relevant when compared with a two-part lifting test.

Based on these considerations, there is a need to develop functional tests that evaluate muscle strength and power through integrated movements involving several muscle groups for both the upper and lower body; e.g., lifting an object and rising from a chair.

1.3.2 Effects of strength-training regimes

It is not clear which form of strength training is most beneficial for the elderly, and there are different views concerning strength-training protocols where the goal is to maintain or attain an adequate level of muscle performance, physical function and to perform ADLs successfully and independently. High-intensity [105–107], low-intensity [108], high-velocity in combination with high-intensity [109–112], high-velocity versus traditional low-velocity resistance training at the same training intensity [113–115], high-velocity versus traditional low-velocity resistance training at different training intensities [116; 117] and functional task-oriented strength training [118; 119] have all been investigated.

A traditional strength-training protocol for the elderly includes high-intensity and low-velocity strength training [106]. High-intensity strength training, equivalent to ~80% of one-repetition maximum (1RM), is effective for increasing muscle size and strength [105–107]. However, this training regime may lead to a lack of muscle power, because of the slow speed of muscle contraction. Using heavy loads (80% of

1RM) during explosive resistance training may be the most effective strategy to achieve simultaneous improvements in muscle strength and power in older adults [97]. Peak muscle power appeared to be improved to similar extents using light, moderate or heavy resistances [97; 120], whereas a dose–response relationship has been observed between different training loads and muscle strength [97]. Power-training studies in the elderly have mostly focused on lower-body power [97; 109; 110; 111; 113; 115; 120]. However, if the goal is to elicit improvements in functional movement capacity among older adults, it is also necessary to integrate the upper body in such training programs and to improve peak power in the upper-body musculature. Furthermore, exercise strategies for the elderly should be designed to increase muscle power in functional movements. However, little is known about the functional adaptive responses of elderly subjects to power training [121]. Table 3 provides an overview of intervention studies in which the authors aimed to study the effect of traditional strength- and power-training protocols in older men and women.

Table 3. The effect of traditional strength training protocol (high-intensity + low-velocity) and power training protocol (high-intensity + high-velocity) in older men (M) and women (W).

	Subjects		Training protocol	Results
Authors	**Age (yr)**	**Sex (N)**		**Muscle strength, muscle power, muscle hypertrophy (muscle growth) and function**
Traditional strength training protocol:				
Frontera et al., 1988 [105]	60-72	M (12)	12-wk intervention period Knee extensor and knee flexor exercises (in machines) 8-rep/set, 3 sets/day, 3days/wk 80% of 1RM[1]	Knee extensor 1RM[1] increased : 107.4% (p≤0.001) Knee flexor 1RM[1] increased : 226.7% (p≤0.001) Mid-thigh muscle area (CT-scan) increased : 11.4% (p≤0.001)
Fiatarone et al., 1990 [106]	90 (SD[5]:1)	W (6) M (4) (9 completed)	8-wk intervention period Knee extensor exercise (in machine) 8-rep/set, 3 sets/day, 3 days/wk 80% of 1RM[1]	Knee extensor 1RM[1] increased: 174.0% (average) Mid-thigh muscle area (CT-scan) increased : 9.0% (p≤0.001) M. Quadriceps negatively correlated with walking time (r = -0.75) 6-m backward tandem walk increased: 48.0%
Taaffe et al., 1999 [107]	65-79	W (17) M (29)	24-wk intervention period Eight exercises (in machines) for upper and lower muscle groups 8-rep/set, 3 sets/day	For each of the eight exercises, muscle strength increased in EX[2] groups relative to CG[3] (p<0.01) No difference among EX1, EX2 and EX3 groups Percent change in muscle strength averaged 3.9±2.4 (CG[3]), 37.0±15.2 (EX1), 41.9± 18.2 (EX2), and 39.7±9.8 (EX3)

			EX[2] groups; 1 (EX1) or 2 (EX2) or 3 (EX3) days/wk 80% of 1RM[1]	Time to rise from a chair 5 times decreased (p<0.01) Changes in chair rise ability (5 times) correlated to % change in M. Quadriceps strength (r = -0.40)
Power training protocol:				
Fielding et al., 2002 [113]	73 (SD[5]:1)	W (30)	16-wk intervention period Leg press (LP) and knee extension (KE) (in machines) 8-10 rep/set, 3 sets/day, 3 days/wk EX[2] groups; high-velocity (HI) and low-velocity (LO) 70% of 1RM[1]	HI higher increase in LP peak power than LO (267 W versus 139 W, p<0.001) HI higher increase in LP power (3.7-fold greater, p<0.001) and KE power (2.1-fold greater, p<0.001) than LO LP 1RM and KE 1RM increased similarly in both HI and LO (p<0.001)
Henwood & Taaffe, 2005 [109]	60-80	W/M (24)	8-wk intervention period Seven exercises (in machines) for upper- and lower muscle groups using explosive concentric movements RCT[4]; EX[2] group (n=14) and CG[3] (n=10) 8 rep/set, 3 sets/day, 2 days/week 75% of 1RM[1]	Dynamic muscle strength (1RM[1]) increased (p=0.001) in EX[2] group for all exercises (from 21.4 ±9.6 to 82.0±59.2%), and so did knee extension power (p<0.01) Improvement occurred for EX[2] group in the floor rise to standing (10.4±11.5%, p=0.004), 6-metre walk (6.6±8.2%, p=0.01), repeated chair rise (10.4±15.6%, p=0.013), and lift and reach (25.6±12.1%, p=0.002) performance tasks but not in CG[3]

de Vos et al., 2005 [97]	69 (SD[5]:6)	W/M (112) W: 61% M: 39%	8 to 12-wk intervention period Five exercises (in pneumatic resistance machines) using explosive concentric movements RCT[4]; intervention groups: G20 (20% of 1RM[1]), G50 (50% of 1RM[1]) and G80 (80% of 1RM[1]) and CG[3] 8 rep/set, 3 sets/day, 2 days/week	Average peak power increased similarly in G80 (14%), G50 (15%), and G20 (14%) compared to [CG3] (3%) (p<0.001) Average strength increased in G80 (20%), G50 (16%), and G20 (13%) compared to CG[3] (4%) (p<0.001)
de Vos et al., 2008 [120]	69 (SD[5]:6)	W/M (112) W: 61% M: 39%	8 to 12-wk intervention period Five exercises (in pneumatic resistance machines) using explosive concentric movements RCT[4]; intervention groups: G20 (20% of 1RM[1]), G50 (50% of 1RM[1]) and G80 (80% of 1RM[1]) and CG[3] 8 rep/set, 3 sets/day, 2 days/week	Force at peak power increased significantly and similarly among G20, G50 and G80 compared with CG[3] Force contributed significantly more to peak power production in G80 and G50 than in the CG[3]

Reid et al., 2008 [115]	74 (SD[5]:7)	W (31) M (26)	12-wk intervention period Leg press and knee extension exercises (in pneumatic resistance machines) RCT[4]; high velocity power training (POW), slow velocity resistance training (STR), and low extremity stretching (CG[3]) 8 rep/set, 3 sets/day, 3 days/week 70% of 1RM[1]	Power output significantly higher in POW compared to STR for knee extension (~2.3-fold) and leg press (~2.8-fold) exercises (p<0.01) Leg press peak power significantly higher in POW compared to STR and GC[3] (p<0.05) Lower extremity power increased similarly from baseline in POW and STR compared to CG[3]
Sayers and Gibson et al., 2012 [111]	70.6 (SD[5]:7.3)	W (50) M (22)	12-wk intervention period Leg press and knee extension exercises (in pneumatic resistance machines) RCT[4]; high speed power training (HSPT) at 40% of 1RM[1], slow speed strength training (SSST) at 80% of 1RM[1], and stretching (CG[3]) 8-10 rep/set, 3 sets/day, 3 days/week	HPST increased peak power and peak power velocity across a range of external resistances (40%-90% of 1RM[1], p<0.05) Work was similar between groups, but perceived exertion was lower in HPST (p<0.05) Less strenuous HPST exerted a broader training effect compared to SSST

[1]*repetition of max*, [2]*exercise*, [3]*control group*, [4]*randomized controlled trial*, [5]*standard deviation*

2. NEED OF NEW INFORMATION

Given the above there is a need of population based studies monitoring physical activity in older adults using consistent, reliable and valid measurement tools, in addition to examine associations between objectively-assessed physical activity level with self-report instruments including simple measures of health. There is a lack of population-based musculoskeletal fitness- and balance data and also its associations with objectively-assessed physical activity levels of individuals 65 years and older. Paper one and two included in this thesis strive to increase the knowledge about physical activity levels and musculoskeletal fitness and balance ability, measured objectively among older Norwegian men and women.

There is also a need of developing valid and reliable functional tests evaluating muscle strength and power through integrated movements for both upper and lower body. Furthermore, exercise strategies for the elderly should be designed to increase muscle strength and power in functional movements. Paper three and four included in this thesis strive to increase the knowledge about valid and reliable functional tests aiming at muscle strength and power, as well as functional adaptive responses of older adults to strength training at high intensity and high velocity.

2.1 Specific aims of Paper I-IV

Specific aims of the separate papers were as follows:

- To describe the level of accelerometer-determined physical activity in a random national sample of Norwegian older adults (65–85 years), and to investigate the association between physical activity level and self-reported health (**Paper I**).

- To describe musculoskeletal fitness and balance in a random national sample of Norwegian older individuals (65-85 years), to examine age- and sex-related differences in musculoskeletal fitness and balance, and to investigate the association between musculoskeletal fitness and balance with objectively-assessed physical activity levels (**Paper II**).

- To test if the field-based 30-s chair-stand test and a modified field-based version of the progressive isoinertial lifting evaluation (PILE) test were valid tests for assessing relationships between: 1) lower extremity strength and muscle power, and 2) total lifting strength and muscle power, in elderly individuals. Additionally, to investigate the reliability across trials (intraday reliability) for the laboratory-based tests and reliability across days (interday reliability) for the field- and laboratory-based tests (**Paper III**).

- To test the effect of traditional versus functional strength training, both performed at 80% of 1RM at a maximal intended concentric velocity, on muscle power and muscle strength measured functionally and traditionally in older adults compared with nontraining-controls (**Paper IV**).

3. MATERAL AND METHODS

3.1 Study design and sampling

3.1.1 Design

Papers I and **II** are based on the KAN1 ("Kartlegging Aktivitet Norge") study, which was carried out in 2008-2010 and is a national cross-sectional multicenter examination of randomly selected 20 to 85 year-old adults and elderly in Norway [122]. KAN1 consists of test phase one (determining physical activity level) and test phase two (determining musculoskeletal fitness level and balance). **Paper III** is a reliability- and validity study and **Paper IV** is a controlled intervention study. All studies include elderly individuals (≥65 years).

3.1.2 Study sample and sample selection

From the Norwegian population registry a representative sample of 2040 individuals aged 65–85 years were drawn from the geographical areas surrounding the involved test centers (three universities and seven university colleges throughout Norway) (**Paper I** and **II**). The participants were randomly selected and stratified based on sex, age and geographical place of resistance. Study information and informed consent (Appendix 1) were distributed via mail to the drawn sample. Written informed consent was obtained from 628 subjects (313 women and 315 men, a total of 31% of the invited sample), and they all went through accelerometer registration. Those with valid accelerometer data (see 3.3.2) were included in the data analysis (n = 560, 282 women and 278 men) in test phase one (**Paper I**) (Figure 1).

Due to limited capacity at the 10 test centers performing the musculoskeletal fitness- and balance testing a total of 30 % of those participating in test phase one was invited to participate in test phase two to assess musculoskeletal fitness level and balance. The participants invited to test phase two were randomly selected and stratified based on sex, age and geographical place of residence (**Paper II**). The participants with both valid accelerometer-determined data and musculoskeletal fitness- and balance measurements (based on strict test procedures, see 3.3.2 and 3.3.4) were included in the final data analysis (n=161, 85 women and 76 men) in test phase two (**Paper II**) (Figure 1).

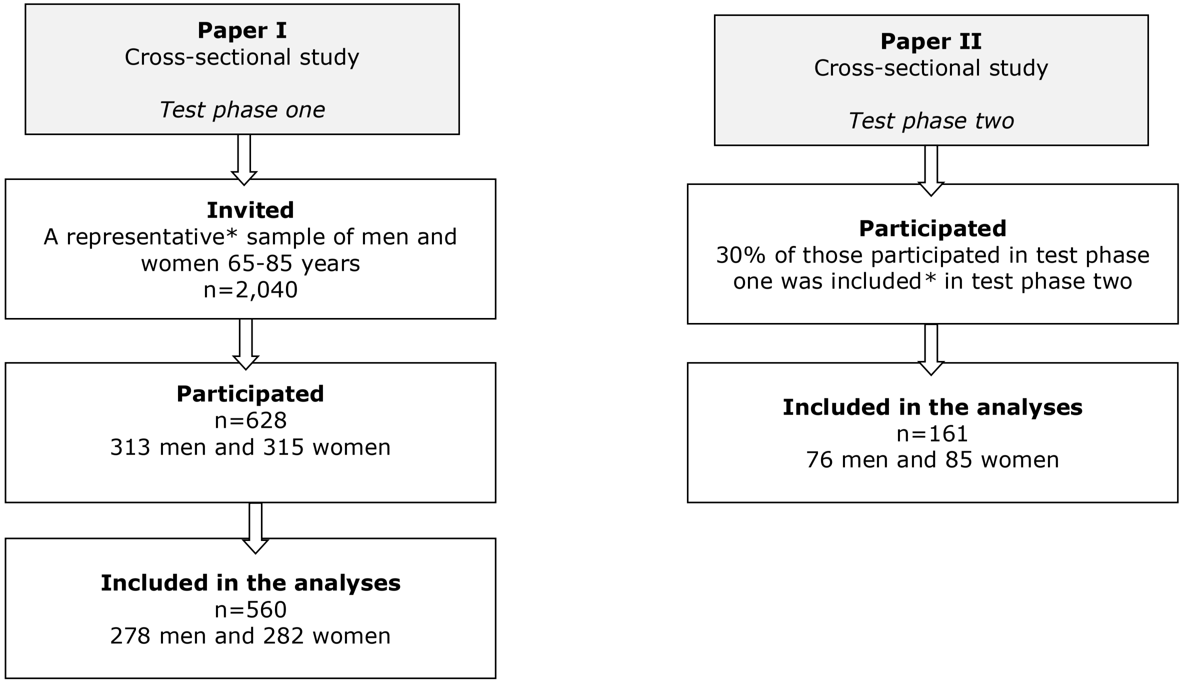

Figure 1. Flowchart of recruited participants into Paper I and II. ** Randomly selected and stratified based on sex, age and geographical place of residence.*

After an advertisement in the local newspaper nineteen elderly individuals (14 men and 5 women) volunteered for the reliability- and validity study (**Paper III**). Prior to participation, all the elderly agreed to an informed consent (Appendix 2) and reported their health history, perceived health status (i.e. very good, good, bad or poor/very poor health) and physical activity level through a questionnaire (Appendix 3) and received a medical clearance from their medical doctor/physician, either in written or verbal form. Comprehensive questions (Appendix 3) asking for details regarding the persons` level of physical activity was used, including activities of daily living and common exercise modes. Inclusion criteria were: 65 years and older and physically active less than 30 min per day at a moderate intensity. Exclusion criteria were: physically active more than 30 min per day at moderate intensity, participating in specific strength training, involved in other studies interfering with the present study, cognitive impairment, acute or terminal illness, or severe cardiovascular-, respiratory-, musculoskeletal-, or neurological diseases disturbing voluntary movement. The inclusion and exclusion criteria were chosen to make sure that the participants were relatively physically inactive and homogenous regarding their health status and physical activity levels. Figure 2 provides a flowchart of recruitment of participants into **Paper III**.

The subjects in the intervention study (**Paper IV**) were also recruited through advertisement in the local newspaper. A total of 110 people showed their interest after the first information meeting. Because of limited capacity, 70 volunteers (35 men, 35 women) were randomly stratified by sex out of the total number of 110. Informed consent (Appendix 2) was distributed to the drawn sample and obtained prior to the project. The subjects were randomized into two intervention groups: a high-power strength group (HPSG, *n* = 25) and a functional strength group (FSG, *n* = 30). Based on the capacity of the fitness center and the number of instructors available, the size of the HPSG was smaller than the FSG. Finally, 15 subjects volunteered to be nontraining-controls (CG) and were therefore a nonrandomized group. Before participation, all subjects reported their health history and physical activity level through a questionnaire (Appendix 3). In addition, they received medical clearance from their medical doctor, either in written or oral form to ensure they were healthy enough to participate. The same inclusion- and exclusion criteria were used in the intervention study as described above in the reliability- and validity study (see **Paper III**). During the study period, the participants were encouraged to maintain their normal physical activity- and dietary patterns. Seven subjects dropped out of the study: two from the HPSG and five from the CG. No drop-outs were registered in the FSG. The final data analyses are therefore based on 23 participants in the HPSG (10 men and 13 women), 30 participants in the FSG (17 men and 13 women), and 10 participants in the CG (5 men and 5 women). Figure 2 provides a flowchart of recruitment of participants into **Paper IV**.

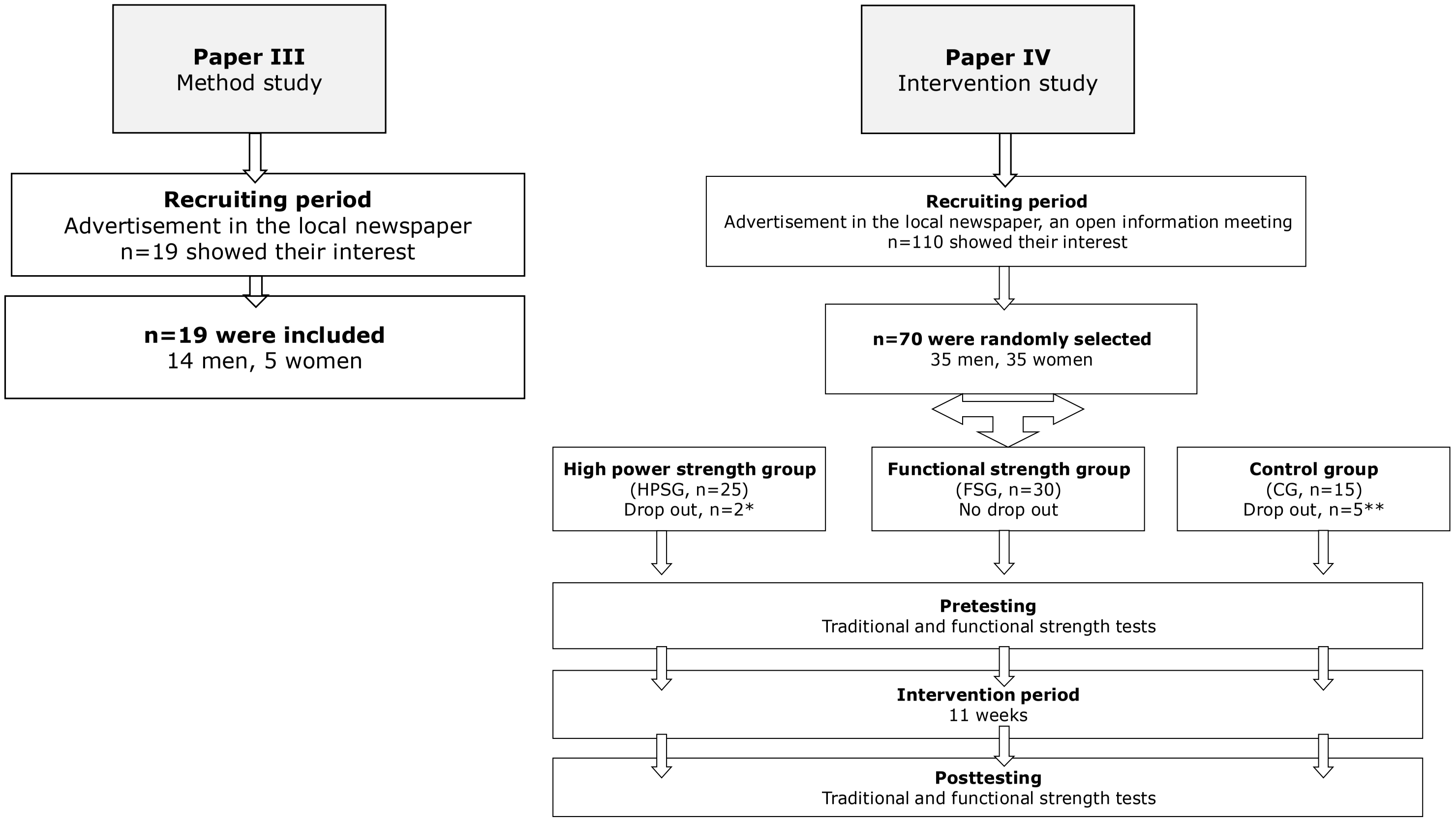

Figure 2. Flowchart of recruited participants into Paper III and IV.* *Two drop-outs from the HPSG for medical reasons (**Paper IV**). ** Five drop-outs from the CG; four for medical reasons and one due to a failure to complete the required number of testing sessions (**Paper IV**).*

The studies were approved by the Regional Committee for Medical and Health Research Ethics and the Norwegian Social Science Data Services AS (Appendixes 4 and 5), and performed by the rules stipulated by the Helsinki declaration.

3.2 Sample size calculation

Paper I and II

A power calculation was conducted in advance of KAN1, which was based on the primary outcome variable overall physical activity level expressed as mean cpm. Calculation was made using a two-tailed test assuming Type 1 error rate=0.05 and statistical power =0.8. The sample size calculations for differences between groups were based on the number required to detect a minimum of 7% difference in cpm, giving a minimum sample size equal to 445 participants in each group. This is based on the total sample, 20-85 years of age. A separate power calculation was not conducted for the target age group 65-85 years old in **Paper I**. However, the number of participants included in this study was considered to be acceptable based on comparable studies [43; 44; 45].

A power calculation was also conducted in advance of test phase two in this cross-sectional study (**Paper II**), which was based on the primary outcome variable aerobic capacity, expressed as VO_{2max} (ml/kg/min). Calculation was made using a two-tailed test assuming Type 1 error rate=0.05 and statistical power =0.8. The sample size calculations for differences between groups were based on the number required to detect a minimum of 5% difference in VO_{2max}, giving a minimum sample size equal to 159 participants. VO_{2max} is not presented in this study. However, the number of participants included in **Paper II** was considered to be acceptable based on comparable studies [81; 83] when using the other physical fitness test variables incorporated in this study, expressed as musculoskeletal fitness and balance capacity.

Paper III

A power calculation was not conducted in advance of the method study (**Paper III**). However, the number of participants included in this study was considered to be acceptable based on comparable studies [123; 124].

Paper IV

A power calculation was conducted in advance of the intervention study (**Paper IV**) based on the work by Henwood and Taaffe [109], looking at the changes in functional muscle strength. The analysis was based on an effect size of 1.0, where the size of the change in functional muscle strength was 10% and the standard deviation of the mean change was 10%. The power analysis gave a statistical power of 81% and alpha error level or confidence level of 5%, giving a sample size in each group of 20 subjects.

3.3 Measures and test procedures

3.3.1 Anthropometry and self-reported background variables

In **Paper I**, the participants` body height and body mass was self-reported through a questionnaire (Appendix 6). Body mass index (BMI) was computed as body mass (kg) divided by height in meters squared (m^2). Self-reported level of education was categorized into four groups: less than high school, high school, less than four years of university education, and university education for four years or more (Appendix 6). In addition, the participants also recorded if they were retired or in part-time/full-time employment (Appendix 6). In **Paper II, III and IV**, body height and body mass were measured to the nearest 0.1 cm and 0.1 kg, respectively, by the use of stadiometers and body mass monitors (Seca opima, Seca, United Kingdom) whilst wearing light clothing and no shoes. BMI was computed after the same method as presented above.

3.3.2 Physical activity assessment

In **Paper I and II**, ActiGraph GT1M accelerometers (ActiGraph, LLC, Pensacola, FL) were used to measure the participants' physical activity level. The accelerometer registers vertical acceleration in units called counts and collects data at a rate of 30 times per second in user-defined sampling intervals (epochs). The number of steps taken per day was registered using the embedded pedometer function [122]. The participants received a pre-programmed accelerometer by mail. They were instructed to wear the accelerometer over the right hip in an elastic band while awake, and to remove the accelerometer when doing water activities. The participants wore the accelerometer for seven consecutive days, and they returned the accelerometer by prepaid express mail after the registration period. We initialized and downloaded the accelerometers using ActiLife software provided by the manufacturer (ActiGraph LLC, Pensacola, FL). Customized SAS based macros (SAS Institute Inc., Cary, NC, USA) were used to reduce the data and derive the following variables: 1) mean counts per minute (cpm) (**Paper I**); 2) number of steps taken per day (spd) (**Paper I**); 3) number of minutes spent in intensity specific categories (sedentary physical activity < 100 cpm [125; 126], low-intensity physical activity 100-759 cpm [47], lifestyle-intensity physical activity 760-2019 cpm [47; 126], moderate-to-vigorous physical activity ≥2020 cpm) [21] (**Paper I**), 4) a daily increment of 1000 steps (**Paper II**) and 5) percentage of the study population meeting the national physical activity recommendations (minimum of 30 minutes of daily moderate physical activity in bouts of 10 minutes or more) [127] (**Paper I**). Physical activity files were deemed valid if a participant accumulated at least 10 hours of valid activity recordings per day for at least four days [128] (**Paper I**) and for at least one day (**Paper II**). Wear time was defined by subtracting non-wear time from 18 hours (all data between 00:00 and 06:00 were excluded). Non-wear time was defined as intervals of at least 60 consecutive minutes with zero counts, with allowance for 1 minute with counts greater than zero [122].

3.3.3 Self-reported perceived health assessment

The participants` self-reported data on perceived health was registered through a questionnaire (Appendix 6) in **Paper I**, and was reported as “very good health”, “good health”, “either good or bad health”, and “poor/very poor health”. Self-reported perceived health scale was condensed from five to four categories. “Very good health”, “good health” and “either good or bad health” were kept in separate categories, while “poor health” and “very poor health” were combined into one category “poor/ very poor health”. This was due to the low numbers in the “poor” and “very poor health” groups.

3.3.4 Musculoskeletal- and balance assessments

The test battery used in **Paper II** included the following tests: one leg standing [129; 161], handgrip strength [130; 131], and static back extension [129; 162]. In addition, the following tests measuring joint flexibility were also included; sit and reach [132; 163] and back scratch, right and left arm over [100].

The One leg standing test [129; 161] is measuring postural control/static balance and the participants were instructed to stand on the optional leg, facing a mark at eye height on the wall three meters away (Figure 3a). The-non-balancing legs heel was to be placed in the knee joint of the supporting leg and the non-balancing legs knee was to be rotated externally. The participants` arms hung alongside their body. One attempt on the optimal leg was carried out, and the total time the participants managed to keep the initial balancing position was recorded in seconds (s) (maximum 0 s, maximum 60 s).

The Handgrip strength test [130; 131] is measuring handgrip strength using a hydraulic dynamometer type baseline 90 kilogram (kg) (Chattanooga, Hixon, USA). The dominant hand was to hold the dynamometer, which was used to record the handgrip strength (Figure 3b). The best of three attempts was recorded to the nearest 1 kg.

The Static back extension test [129; 162] is measuring endurance capacity of the trunk extensor muscles and the participants were asked to lay face down on a 30 cm tall, 18 cm broad and 135 cm long bench with their iliac crest lined with the bench's short side, leaving the upper body beyond the bench and their legs fixed on the bench (Figure 3c). The participants were instructed to hold their upper body in a horizontal position for as long as they could and the time (in sec) the participants managed to hold the horizontal position was recorded. One attempt was carried out, and the result was recorded in s (minimum 0 s, maximum 240 s).

The Sit and reach test [132; 163] is measuring flexibility of the lower back and hamstring musculature. A standardized box (the length of top of the box was 53.3 cm and the height was 32.5 cm) was placed to a wall and the participants sat on the floor with their knees and upper body straight, and their heels against the box (Figure 3d). The participants leant as far as possible along the measuring tape atop of the box, with one hand on top of the other slide along the box and with the back and legs straight. The furthest the participants managed to stretch their hands along the measuring tape and hold for two sec, was recorded to the nearest half cm. Point zero, the point where the feet met the box was set at 23 cm from the box's edge, and the recorded result was 23 cm plus or minus the distance from point zero, depending on what side of point zero the final reach was recorded. One attempt was carried out, and the result was recorded to the nearest half cm.

The Back scratch test [100] is measuring flexibility in the shoulder joint and shoulder arch on the right and on the left side. The participants started the test by standing up right, placing one arm/hand on the lower back, moving it up the spine toward their head. The opposite arm/hand was placed behind their neck, moving it down the spine, aiming to place the long finger of each hand as near each other as possible or to overlap the other hand as much as possible (Figure 3e). The procedure was repeated with opposite arm/hand. The gap between the fingertips of the long finger of both hands was measured to the nearest half cm. The results were recorded to the nearest half cm, with positive numbers if the fingers overlapped and with negative numbers if the fingers did not meet. One attempt was carried out on each side (right and left arm over), and the result was recorded to the nearest half cm.

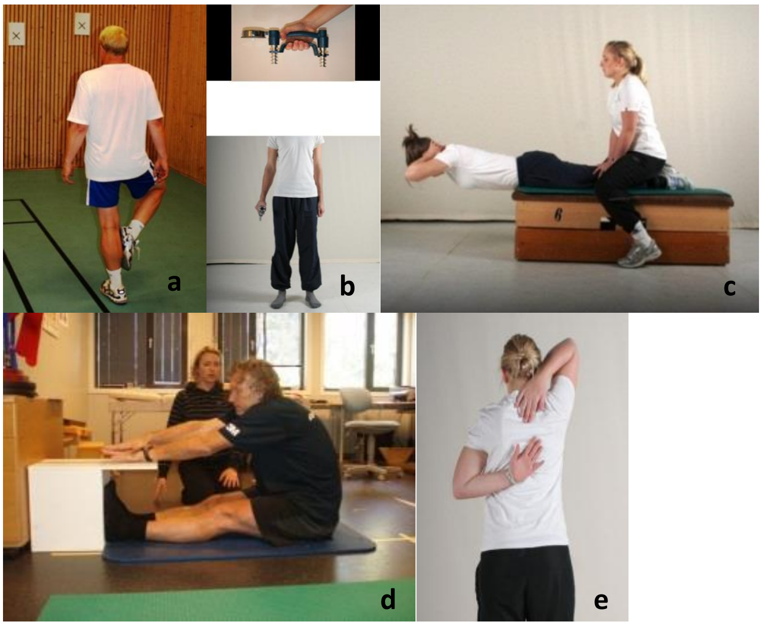

Figure 3a-e. The musculoskeletal fitness- and balance tests used in Paper II.

3.3.5 Field- and laboratory based chair-stand and box-lift tests

In **Paper III**, the participants completed a 15-min warm-up before testing, which included fast walking and active arm movements, as well as 3-5 min of upper and lower extremity muscle stretching. The warm-up routine was performed to ensure the participants were physically prepared for the strength testing and to decrease injury risk. Testing was completed on two occasions, 3-4 days apart and at the same time of the day to quantify test-retest reliability across days (interday reliability). A comparison was made between the field-based tests (CS_{field}, $\text{PILE}_{\text{field}}$) and the laboratory-based tests (CS_{lab}, PILE_{lab}) to determine test validity: The number of unsupported chair stand repetitions in the CS_{field} test was compared with the calculated average power during single "as fast as possible" sit to stand movements performed on a force platform (CS_{lab} test), and the maximum load lifted in the modified version of the $\text{PILE}_{\text{field}}$ test was compared with the calculated average power directly measured with the linear encoder attached to the box during single "as fast as possible" box lifting trials (PILE_{lab} test). The procedures for the laboratory-based tests (CS_{lab}, PILE_{lab}), were established based on a pilot study including n=6 participants aged 65+. The same test procedures were followed at day one and day two. To minimize muscle fatigue in the working muscle groups, the tests were carried out in the following order; 1RM isometric dead lift test, $\text{PILE}_{\text{field}}$, CS_{field}, PILE_{lab} and CS_{lab} tests.

The 1RM Isometric Deadlift test measured peak isometric force using a tension load cell (Figure 4) which was connected to an integrated data analysis program (Muscle Laboratory, Ergotest Technology AS, Norway by Olsen [134]). The participants were encouraged to exert maximal force during the test. The best, of two attempts was recorded. A total of 10% (women) and 15% (men) of the "average" maximum loads (kg) were calculated and then used during the PILE_{lab} test. The working intensity (10 and 15% of 1RM isometric dead lift test for women and men, respectively) in the PILE_{lab} test was established in a pilot study in order to make sure that the participants followed correct ergonomic principles (box close to body, bended knees and straight back) and therefore reduced the risk of injuries during the lifts.

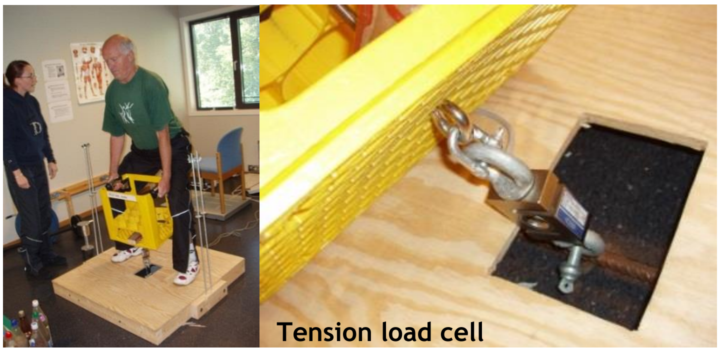

Figure 4. The 1RM Isometric Deadlift test used in Paper III.

The $\text{PILE}_{\text{field}}$ test was used to measure the ability to lift loads rapidly (total lifting strength), and consisted of repeated lifts of a progressively heavier box from floor to chin height in one continuous movement (Figure 5a). To make sure the participants performed the $\text{PILE}_{\text{field}}$ test correctly they were asked to start the lift with bent knees and elbows, the box close to their body and a straight back. Whilst extending the knees and elbows, the box went up to chin height in one continuous movement. In addition, to better control for a straight vertical movement of the box, the participants were asked to look straight ahead. During the lifts, the movement techniques were observed by an instructor at all times, in order to ensure the correct techniques were used. The participants lifted a light (1 kg) box in which sand-filled containers weighing 2.25 kg each were placed in order to increase the load incrementally during the test. The women started the test lifting the box filled with one container (2.25 kg) and the men started by lifting the box with two containers (4.5 kg). The participants were encouraged to work as fast as possible and exert maximal power (a combination of fast speed and explosive work) during the box lifting. The load was increased every 20 s by 2.25 and 4.5 kg for the women and men, respectively, until a maximum lifted load was achieved (when the participants could no longer lift the box using the correct technique). The total load lifted in the final repetition was taken as the participant's final result.

The PILE$_{lab}$ test was used to measure lifting power capacity, and was performed using linear encoder and load cell connected to the integrated software system (Figure 5b). To make sure the participants performed the PILE$_{lab}$ test correctly they were asked to use the same procedures as described in the PILE$_{field}$ test. The participants were encouraged to work "as fast as possible" during the box lifting. Power output was measured as vertical force times distance divided by time. The average of the two best trials out of five (approximately 2 s between each trial) was recorded as the result. During the PILE$_{lab}$ test, the women lifted 10% and the men 15% of the maximum achieved result during a maximal isometric deadlift test performed 45-60 min prior to the PILE$_{lab}$ test.

Figure 5a) the PILE$_{field}$ test and **5b)** the PILE$_{lab}$ test used in Paper III.

The CS_{field} test was used to measure the ability to accomplish repetitive chair-stand rapidly (lower extremity strength). The participants started the test sitting on a chair (height 46.0 cm, depth 44.5 cm), with the arms across the chest, their back touching with the chair's backrest, the feet shoulder-width apart and the knees flexed to 90° (Figure 6a). They were asked to stand up to a straight position and re-sit as many times as possible in 30 s, without pushing off with their arms. The participants were encouraged to work "as fast as possible" during the chair standing. The number of repetitions completed in 30 s was taken as a measure of performance.

The CS_{lab} test was used to measure lower extremity power and was performed on a force platform connected to the integrated software system (Figure 6b). The participants started the test sitting on the same chair that was used for the CS_{field} test, and the arms, back and feet in the same position as described above. When signaled, the participants were asked to stand up to a straight position as fast as possible, without pushing off with their arms, and then slowly sit back on the chair seat. Power output was measured as vertical force times distance divided by time. The average of the two best trials of five (approximately 2 sec between each trial) was recorded as the result.

Figure 6a) the CS_{field} test and **6b)** the CS_{lab} test used in Paper **III**.

3.3.6 Strength- and power tests

In **Paper IV**, participants completed a 30-min warm-up on a cycle ergometer (Monark, 818 E, Ergomed) on the first test day, before undergoing the traditional strength tests (leg-press, Smith-machine bench-press, and 1RM isometric dead-lift tests). On the second test day (1 week after the first test day), the participants completed a 30-min warm-up including fast walking and stair climbing before the functional strength tests (sit-to-stand power and box-lift power tests).

<u>The Leg-Press tests:</u> 1RM leg-press force and 80% of 1RM leg-press power were determined using a linear encoder and load cell connected to the integrated data analysis program (Muscle Laboratory, Ergotest Technology AS, Norway) as described above. The subjects were encouraged to exert maximal force during the bilateral 1RM testing [134]. To measure 80% of 1RM leg-press power, the subjects were asked to complete the concentric phase of the movement as rapidly as possible and then return through the eccentric phase at a slow and controlled pace over 2–3 s. The average of the two best attempts of five was recorded as the result. The same load lifted at 80% of 1RM at pre-intervention testing was used on the post-intervention testing to reveal possible power changes for a given load.

<u>The Bench-Press tests on the Smith Machine:</u> 1RM bench-press force and 80% of 1RM bench-press power were determined using a linear encoder and load cell connected to the same integrated data-analysis program described above. Identical test procedures were followed as during the leg-press tests.

Concerning the 1RM Isometric Deadlift test, Sit-to-Stand Power test (here the test is named CS_{lab} test), and Box-Lift Power test_(here the test is named $PILE_{lab}$ test): see the description of the tests under 3.3.5.

3.3.7 Exercise intervention

The two intervention groups outlined in **Paper IV** exercised twice a week for 11 weeks, with at least 48 hours between the two training sessions. The exercise program in the two intervention groups consisted of a 10-min warm-up including instructed aerobic and stretching exercises, followed by 50 min of instructed strength training using machines, called high power strength training (HPSG) or functional strength training (FSG). Finally, a 10-min cool-down consisting of lower back, abdominal, and stretching exercises was completed under supervision in both intervention groups.

HPSG subjects completed the following strength-training exercises in each training session: seated row, lat pull-down, shoulder press, leg press, and multipower bench press on a Smith machine (Figure 7). The exercises were performed on TechnoGym equipment (Silver Line/Selection, Italy).

Figure 7. Photos showing the machine-based strength training exercises.

FSG subjects completed the following functionally based exercises in each training session: stair climbing using a backpack filled with training weights as the external load, box lifting using 2.25-kg bottles filled with sand as the external load, shoulder press and one-arm flies using dumbbells as the external load, and “rubber band rowing” using three different-resistance rubber bands as the external load (Figure 8). In addition, the participants in the FSG worked in an obstacle course consisting of sit-to-stand from a chair, hurdles, balance, and slalom challenges. They were asked to complete the obstacle course as correctly and quickly as possible.

Figure 8. Photos showing a selected sample of the functional-based exercises.

All participants worked in pairs and were supervised by an instructor whose responsibility was to maintain set protocols and to establish a standard of security and motivation. Five instructors were engaged throughout the 11-week intervention, and each instructor was responsible for the same exercises in the training period. The same training protocol was used as described in Jozsi et al. [135] and Henwood and Taaffe [109]. The focus in the first 2 weeks (equivalent to four training sessions) of the training period was for the subjects to learn how to do the exercises, establish good training routines for the couples who worked together, get used to the training environment, and gain muscle conditioning.

The first four training sessions had the following training protocol:

- For each exercise the participants completed three sets of six to eight repetitions at 60% of 1RM in the first set and 70% of 1RM in the second and third sets.
- Concentric and eccentric movements were performed in 2–3 s each.

The rest of the intervention period (equivalent to 18 training sessions) had the following training protocol:

- The training aimed specifically at increasing muscle power by using rapid concentric movements and increasing resistance intensities.
- Three sets of eight repetitions were performed at 60% of 1RM in the first set and 80% of 1RM in the second and third sets.

- The participants were instructed to perform the concentric phase of the movement as rapidly as possible, then return through the eccentric phase at a slow and controlled pace of 2–3 s.
- In the third set of exercises on the second training day each week, the subjects were asked to work past the eighth repetition until failure. If they managed to do 10 repetitions, the 1RM was increased by 5%. If they managed to do 12 repetitions, the 1RM was increased by 10%. The 1RM training percentages were then recalculated accordingly.

Subject participation was recorded at every training session and they were allowed to be absent three times during the 22-session intervention period. No participants in the intervention groups were excluded from the study based on adherence less than 19 training sessions.

3.4 Statistical analysis

In **Paper I:** Student's t-tests for independent samples were used to assess differences in continuous variables (age, height, body mass, BMI, number of minutes spent in intensity-specific categories) between women and men in the different age groups. Pearson's chi-square analyses were used to identity differences between the sexes in education level, self-reported health, and in the proportion of participants from each sex who adhered to the current PA recommendations. ANOVA with Bonferroni adjustments were used for comparisons between multiple groups. Linear regression analysis was used to estimate changes in physical activity level with increasing age.

In **Paper II:** Based on the Kolmogorov-Smirnov test we considered the data normally distributed. Data are presented as mean and standard deviations (SD), standard errors (SE), or 95% confidence interval (CI) when appropriate. Sex and age differences in the test results (one leg standing, handgrip strength, static back extension, sit and reach, back scratch right and left arm over) were examined using ANOVA. When examining differences between age groups (65-69 years, 70-74 years, 75-79 years, and 80-85 years), we adjusted for sex and test center, and when examining differences between sexes in the various tests, we adjusted for age and test center. When presenting total values, we adjusted for sex, age, and test center. When we examined differences in musculoskeletal fitness- and balance tests in the different age groups the first step was to test the two-way interaction between sex and age groups, by using general linear model. As no significant interaction was found in neither of the variables the analyses were run for both sexes combined.

Linear regression analyses were used to investigate how physical activity level (expressed as 1,000 steps increments to aid interpretation of the beta coefficients) was associated with the different musculoskeletal fitness- and balance tests. The musculoskeletal fitness- and balance tests were the dependent variables and 1,000 steps increments as the continuous, independent variables. Separate regression models were constructed for each predictor. Crude and adjusted regression coefficients are displayed. Significant interactions between sex*steps and handgrip strength-, sit and reach- and back scratch tests were present. However, running the analyses by sex did not alter any associations in a meaningful way and the analyses are therefore run on the whole sample including age, sex, daily accelerometer wear time and test center as covariates.

In **Paper III:** To determine whether five repeated measurements on the same day were similar (intraday reliability), Intra-class correlations (ICCs, one-way random effects model) with 95% confidence interval (CI) were computed to calculate the correlations across trials for CS_{lab} and $PILE_{lab}$ tests, and repeated measures ANOVAs with pairwise comparisons were used to analyze the mean differences across trials (mean ± SD). Day one was used for the five repeated trials analysis. To determine test-retest reliability from day one to day two (interday reliability), ICCs (one-way random effects model) with a 95% CI were calculated to determine reliability across days for CS_{field}, CS_{lab}, $PILE_{field}$ and $PILE_{lab}$ tests, and a paired-samples t-test was used to examine the mean differences from days one to two. Descriptive statistics for the field- and laboratory-based tests at day one and day two were also computed.To determine the validity between the two test performances (field- and laboratory-based tests), ICCs (two-way mixed model) with 95% CI were computed. Data obtained on test day one were used for the validation analysis.

In **Paper IV:** One-way ANOVA with Bonferroni's post hoc test was used to analyze differences between groups at baseline, in addition to analyze differences in the change in performance from pre- to post intervention testing between the three groups (HPSG, FSG, and CG). Within-group comparisons were made using Student's paired-sample t-tests.

Statistical analyses were conducted using IBM SPSS Statistics 19 (**Paper I and II**) and 13 for Windows (IBM Corporation, Route, Somers, NY, USA) (**Paper IV**), and Microsoft Excel and PASW Statistics 18 (**Paper III**). A two-tailed alpha level of $p \leq 0.05$ was used for statistical significance for all four papers.

4. SUMMARY OF RESULTS

4.1 Participants` characteristics (Papers I-IV)

Four groups of participants participated in **Paper I** to **IV**. The participants` anthropometric data are shown in Table 4. In **Paper I** the mean age (SD) was 71.8 (5.6) years for women and 71.7 (5.2) years for men. Men had significantly higher BMI compared to women ($p<0.001$). In **Paper II** the mean age (SD) was 73.2 (5.4) years for women and 72.3 (4.8) years for men. No significant differences in BMI were observed in men compared to women. In **Paper III** the mean age (SD) of the total sample was 72.4 (5.0) years. In **Paper IV** the mean age (SD) of the total sample was 69.9 (4.1) years and no significant differences in the subjects` characteristics were observed between the three groups at baseline.

Table 4. The anthropometrical characteristics of the subjects (Papers I-IV). *Data are presented as mean (SD)*

	All	**All**		**HPST**[a]	**FSG**[b]	**CG**[c]
Variable		**Women**	**Men**			
PAPER I (n)		282	278			
Age (yr)		71.8 (5.6)	71.7 (5.2)			
Height (cm)		163.8 (5.4)	177.1 (6.7)*			
Body mass (kg)		66.4 (10.2)	81.0 (11.9)*			
BMI (kg/m^2)		24.7 (3.6)	25.8 (3.2)*			
PAPER II (n)	161	85	76			
Age (yr)	72.7 (5.1)	73.2 (5.4)	72.3 (4.8)			
Height (cm)	168.4 (9.5)	161.6 (6.0)	175.9 (6.6)*			
Body mass (kg)	74.0 (13.4)	67.0 (10.1)	81.4 (12.2)*			
BMI (kg/m^2)	26.0 (3.5)	25.7 (3.9)	26.4 (3.0)			
PAPER III (n)	19	5	14			
Age (yr)	72.4 (5.0)					
Height (cm)	175.0 (8.6)					
Body mass (kg)	71.4 (9.1)					
BMI (kg/m^2)	23.1 (2.1)					
PAPER IV (n)				23	30	10
Age (yr)[d]				69.4 (4.0)	70.4 (4.3)	69.3 (4.2)
Height (cm)[d]				172.1 (8.8)	172.6 (9.8)	174.3 (10.0)
Body mass (kg)[d]				75.6 (14.8)	79.2 (11.0)	79.3 (18.0)
BMI (kg/m^2)[d]				25.4 (3.7)	26.4 (2.9)	25.9 (4.3)

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*[a]HPSG: high power strength group; [b]FSG: functional strength group; [c]CG: control group; *$p \leq 0.05$ between sexes; [d]No significant differences in the subjects characteristics were found between the three groups at baseline*

The education level and self-reported health among the participants included in **Paper I** are shown in Table 5. Overall, 34% of the participants reported an education level less than high school, 36% reported completed high school, and 30% reported to have a university education. The majority of the study sample reported having a ”good health” (55.9% of women and 51.2% of men, p>0.05) or “either good or bad health” (21.7% of women and 27.8% of men, p>0.05)[1].

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[1] Corrections have now been made based on what is written in **Paper I**; “The majority of the study sample reported having “very good health” (22.3% of women and 16.3% of men) or ”good health” (56.2% of women and 53.7% of men)”.

Table 5. Education level and self-reported health of the study sample (n=560) by age and sex (Paper I)

	65-69 yr		70-74 yr		75-79 yr		80-85 yr		All	
Variable	**Women**	**Men**	**Women**	**Men**	**Women**	**Men**	**Women**	**Men**	**Women**	**Men**
n	127	116	67	79	51	55	37	28	282	278
Education level (%)										
< High school	38.8	28.1	37.3	38.0	42.0	25.9	26.8	38.7	37.3	31.6
High school	35.7	35.5	41.8	31.6	32.0	40.7	34.1	38.7	36.2	35.8
....University <4 yr	10.9	20.7	11.9	20.3	20.0	16.7	24.4	9.7	14.6	18.6
....University ≥4 yr	14.7	15.7	9.0	10.1	6.0	16.7	14.6	12.9	11.8	14.0
Self-reported health (%)										
….Very good	22.3	16.3	20.9	23.5	9.8	10.9	14.3	18.8	18.6	17.5
….Good	56.2	53.7	56.7	49.4	62.7	54.5	45.2	40.6	55.9	51.2
….Either good or bad	19.2	27.6	19.4	27.2	23.5	27.3	31.0	31.3	21.7	27.8
….Poor/very poor	2.3	2.4	3.0	0.0	3.9	7.3	9.5	9.4	3.8	3.4

No significant differences were found in education level and self-reported health between sexes within age group and between sexes within “all”

4.2 Description of physical activity level and its associations to self-reported health (Paper I)

A total of 560 participants had valid activity registrations. Overall, physical activity level (cpm) was significantly different between the age groups (65-69, 70-74, 75-79 and 80-85 years), except between the age groups 65–69 and 70–74 years (Figure 9). This accounted for an overall physical activity level difference of 21% ($p = 0.003$) between the 70-74 and 75–79 years age groups, and a 32% ($p = 0.004$) difference between the 75–79 and 80–85 years age groups. The oldest participants (80–85 years) displayed a 50% ($p < 0.001$) lower activity level compared with the youngest participants (65–70 years). There were no significant differences in overall physical activity level (cpm) or steps taken per day between women and men within the different age groups.

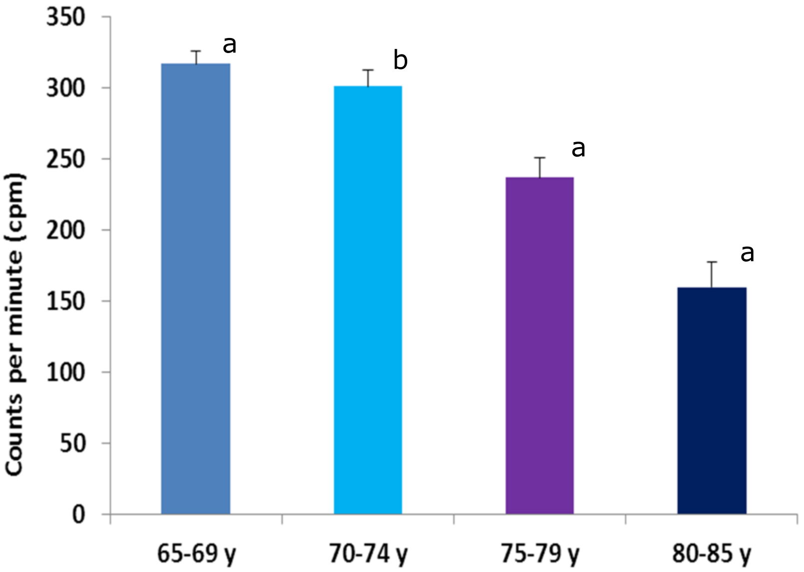

Figure 9. Mean (SEM) overall physical activity levels in counts per minute (cpm) in the different age groups. *a-b: Equal letter indicate significant difference ($p \leq 0.05$) in overall physical activity level between the different age groups.*

When using the data to simulate a longitudinal trend, the regression analysis revealed that the decline was equivalent to a rate of 9 cpm (2.8%) per year (B = -

9.4, $p < 0.001$, 95% confidence interval (CI): -7, -12), and the step variable displayed a yearly decrease of 215 steps (B = -215, $p < 0.001$, 95% CI: -263,-168).

In the two youngest age groups (65-69 years and 70-74 years), men spent more time being sedentary compared with women (558 vs. 535 min ($p = 0.02$) and 554 vs. 525 min ($p = 0.03$), respectively). Women in all age groups, except for the oldest (80-85 years), spent more minutes in low-intensity physical activity compared with men (223 vs. 192 min ($p < 0.001$), 223 vs. 187 min ($p < 0.001$) and 200 vs. 179 min ($p = 0.05$), for the 65-69, 70-74, 75-80 year age groups, respectively). No significant sex differences were found within age group when looking at the time spent in lifestyle physical activity. There was a decline in the proportion of time spent in MVPA when comparing the youngest age group with the oldest (34 vs. 9 min, $p < 0.001$). A difference between the sexes was only apparent in the 75-79-yr age group where men spent significantly more time in MVPA compared with women. Of the waking hours per day, the whole sample spent 9.3 hours (66%) being sedentary, 3.3 hours (24%) in low-intensity physical activity, 1 hour (7%) in lifestyle physical activity and 30 minutes (3%) in MVPA.

A total of 21% of the participants fulfilled the current Norwegian physical activity recommendations (2004) of 30 minutes of daily moderate physical activity, accumulated in bouts of 10 minutes or more. The adherence to the recommendations decreased markedly with increasing age and among the 80-85 year-olds 6% adhered to the recommendations. A difference between the sexes were only observed in the 75-79-yr group where men had a significant higher adherence to physical activity recommendations than women ($p = 0.01$).

Physical activity levels differed across categories of self-reported health. A 51% higher level of physical activity was registered in those reporting “very good health” compared to those reporting “poor/very poor health” (344 (13) vs. 170 (33) cpm, respectively ($p < 0.001$)), and a 43.3% higher level of physical activity was registered in those reporting “good health” compared with those reporting “poor/very poor health” (300 (8) vs. 170 (33) cpm, respectively ($p = 0.001$)).

4.3 Description of musculoskeletal fitness- and balance capacity and its association to physical activity level (Paper II)

The participants in the youngest age group (65-69 years) had significant better results in one leg standing test compared with the participants in the older age groups; 65-69 years compared with 70-74 years: 9.2 s difference (p=0.04), 65-69 years compared with 75-79 years: 17.4 s difference ($p \leq 0.001$), and 65-69 years compared with 80-85 years: 23.0 s difference ($p \leq 0.001$). The difference was equivalent to three times greater static balance in the youngest age group than in one of the older ones (75-79 years). The youngest age group (65-69 years) had also significantly better results in static back extension test compared with the participants aged 75-79 years: 27.8 s difference (p=0.03). The difference was equivalent to two times greater muscular endurance in trunk extensors in the youngest age group than in one of the older ones (75-79 years). No statistical age differences were found in the other musculoskeletal fitness test results.

The mean sit and reach result was significantly better in older women (65-85 years) compared with older men (65-85 years) (7.0 cm difference, $p \leq 0.001$). Both the mean back scratch right- and left arm over results were also significantly better in women compared with men (6.1 cm difference (p=0.01) and 6.7 cm difference ($p \leq 0.001$), respectively). The difference was approximately two times greater body flexibility in women than in men. Also, women had significantly better mean static back extension results compared with men (16.0 s difference, p=0.02). The difference was approximately one and a half times greater muscular endurance in trunk extensors in women than in men. Handgrip strength was significantly higher in men compared with women (16.8 kg difference, $p \leq 0.001$). The difference was approximately two times greater handgrip strength in men than in women. No significant sex differences were found in mean one leg standing result.

A daily increment of 1,000 steps was associated with better test scores for the one leg standing test and the static back extension test in older adults (65-85 years). For the one leg standing test, an increase of 1,000 steps per day was associated with approximately 2 s improved performance on the test ($b=1.88$, 95% CI: 0.85 to 2.90, $p \le 0.001$), equivalent to 9.6%. For the static back extension test, an increase of 1,000 steps per day was associated with approximately 5 s improved performance on the test ($b=4.63$, 95% CI: 1.98 to 7.29, $p=0.001$), equivalent to 8.9%. No other associations were found between steps and musculoskeletal fitness tests (hand grip-, sit- and reach-, and back scratch tests) (Table 6).

Table 6. Associations between 1000 steps increments and the different musculoskeletal fitness- and balance variables

	Crude **B (SE)**	**95% CI**	**Adjusted*** **B (SE)**	**95% CI**
	OLS (s)			
1,000 steps increments	2.32 (0.48)**	1.36 to 3.28	1.88 (0.52)***	0.85 to 2.90
	HG (kg)			
1,000 steps increments	0.22 (0.32)	-0.41 to 0.84	-1.33 (0.24)	-0.61 to 0.34
	SBE (s)			
1,000 steps increments	5.16 (1.21)**	2.77 to 7.55	4.63 (1.34)***	1.98 to 7.29
	SR (cm)			
1,000 steps increments	0.44 (0.29)	-0.14 to 1.02	0.15 (0.31)	-0.47 to 0.77
	BSR (cm)			
1,000 steps increments	0.68 (0.31)**	0.06 to 1.29	0.38 (0.35)	-0.31 to 1.067
	BSL (cm)			
1,000 steps increments	0.76 (0.32)**	0.13 to 1.39	0.59 (0.35)	-0.10 to 1.29

*Abbreviations: OLS: one leg standing; HG: handgrip; SBE: static back extension; SR: sit and reach; BSR: back scratch right arm over; BSL: back scratch left arm over; *The adjusted models include age, sex, daily accelerometer wear time, and test center as covariates; **p<0.05 between 1000 steps increments and test score; ***p<0.001*

4.4 Reliability and validity of chair-stand and box-lift tests (Paper III)

Intraday reliability of laboratory-based tests (CS_{lab} and $PILE_{lab}$); The intra-class correlations (ICC) computed across five repeated trials for CS_{lab} and $PILE_{lab}$ tests performed at day one were high to very high, ranging 0.81-0.99 ($p<0.01$) and 0.92-0.98 ($p<0.01$), respectively. The 95% CIs were in an acceptable range for $PILE_{lab}$ and for CS_{lab} (0.90-0.98 and 0.67-0.87, respectively). ICCs for both CS_{lab} and $PILE_{lab}$ were least (0.81, $p<0.01$ and 0.92, $p<0.01$, respectively) between the first and the fourth trials and greatest (0.98, $p<0.01$ and 0.98, $p<0.01$) between the second and third trials. No significant mean differences across trials were revealed.

Interday reliability of field-based tests (CS_{field} and $PILE_{field}$) and laboratory-based tests (CS_{lab} and $PILE_{lab}$); Test-retest correlations across days for CS_{field}, CS_{lab}, modified $PILE_{field}$ and $PILE_{lab}$ tests were respectively moderate, very high, very high and high, with ICCs ranging 0.71-0.95 ($p<0.01$). The 95% CIs were in an acceptable range for CS_{lab} and $PILE_{field}$ (0.86-0.98 and 0.84-0.91, respectively) but in an unacceptable range for CS_{field} and $PILE_{lab}$ (0.38-0.89 and 0.52-0.93, respectively). No significant mean differences from day one to day two were revealed for these tests.

Relationships between field- (CS_{field} and $PILE_{field}$) and laboratory-based test performances (CS_{lab} and $PILE_{lab}$); ICCs between the field and laboratory versions of CS and PILE tests performed on day one were weak (0.36, $p=0.49$) and strong (0.72, $p=0.48$), respectively, with the 95% CIs in an unacceptable range (-0.44-0.45 and -0.47-0.49, respectively). The validity of the field-based chair-stand and box-lift tests was deemed to be poor when compared to the laboratory-based test.

4.5 Effects of traditional strength training versus functional strength training (Paper IV)

Sit-to-stand power test; No significant differences in percent change from pre- to post intervention were found in the sit-to-stand power test between the three groups (HPSG: 14.5%, FSG: 9.7% and CG: -4.1% ($p=0.101$)). Within group improvements from pre- to post intervention in the sit-to-stand power test were only found in FSG (9.7%, p=0.004).

Box-lift power test; No significant differences in percent change from pre- to post intervention were found in the box-lift power test between the three groups (HPSG: 19.2%, FSG: 9.7% and CG: 3.3% (p=0.135)). Within group improvements from pre- to post intervention in the box-lift power test were found in both HPSG (19.2%, p<0.001) and FSG (9.7%, p=0.006).

Leg-press force (1RM) test; Both HPSG and FSG significantly improved their leg-press maximum force from pre- to post intervention (19.8% (p<0.001) and 19.7% (p<0.001), respectively) compared with CG (4.3%) (p=0.026).

Leg-press power (80% of 1RM) test; No significant differences in percent change from pre- to post intervention were found in the leg-press power test between the three groups (HPSG: 0.3%, FSG: 2.9% and CG: 16.6%) (p=0.176)). Within group improvements from pre- to post intervention in the leg-press power test were found in CG (16.6%, p=0.041).

Bench-press force (1RM) test; No significant differences in percent change from pre- to post intervention were found in the bench-press maximum force test between the three groups (HPSG: 15.2%, FSG: 12.9% and CG: 14.7% (p=0.502)). Within group improvements from pre- to post intervention in the bench-press maximum force test were found in both HPSG (15.2%, p<0.001) and FSG (12.9%, p<0.001).

Bench-press power (80% of 1RM) test; HPSG significantly improved bench-press power from pre- to post intervention (25.1%, p=0.003), and this change was significantly different from both FSG (0.5%, *p*=0.02) and CG (2.0%, p=0.04) (p=0.013).

5. GENERAL DISCUSSION

The following general discussion will primarily focus on the main results, study design, strengths and limitations.

5.1 Physical activity and its association with self-reported health in older adults (Paper I)

The results in **Paper I** show that the objectively measured physical activity level differed significantly with age among older adults living in Norway, where the oldest subjects (80–85 years) displayed a 50% lower activity level compared with the youngest (65–69 years) participants. This is in accordance with other cross-sectional studies using the same objective method [18; 21; 41; 43–45] (see Table 1). Our population appeared to have somewhat higher overall physical activity levels than has been reported for corresponding age groups in other studies from the USA [21; 41], the UK [43] and Iceland [45]. One might speculate that this is because of differences in socioeconomic status, cultural differences with respect to retirement age, infrastructure and degree of environmental security among the populations studied. However, the activity level found in Norway was similar to the level reported in Sweden [46].

No sex-related differences in overall physical activity level within each age group (65–69 years, 70–74 years, 75–79 years, 80–85 years) were observed among older Norwegian adults, which is in contrast to similar studies from other countries that usually showed a higher mean physical activity level among men than women [18; 41; 42; 43; 44; 45]. This might be related to cultural differences such as sex roles and gender equality.

Overall, the older adults spent the majority of their waking hours being sedentary (66% of the total wear time), and this was followed by low-intensity physical activity (24%), lifestyle physical activity (7.1%) and MVPA (3.0%). These findings were comparable with those reported among older adults in Iceland [45], the UK [43] and Canada [42]. Katzmarzyk et al. [136] have shown a dose-response association between sitting time and mortality from all causes, independent of leisure time physical activity. Van der Ploeg et al. [137] also have shown that prolonged sitting is a risk factor for mortality from all causes, independent of physical activity. A recently published study by Schmid et al. [138] concluded that high levels of sedentary time and low levels of MVPA are both strong and independent predictors of early death from any cause. However, because of several methodological challenges when performing such analyses, there is no consensus with respect to the independent effect of sedentary time when adjusted for physical activity [138]. Nevertheless, the large proportion of the elderly who are sedentary and have low levels of physical activity is worrying because it might lead to significant health problems, including a reduced quality of life and an increased need for assistance [38]. Public health programs should therefore focus on increasing physical activity levels, in addition to reducing sedentary time for extended periods in older adults. Older Norwegian women spent more time in low-intensity physical activity and less time being sedentary and in MVPA compared with their male counterparts. This might be explained by older women performing more activities with lighter intensity such as washing dishes, hanging washing, ironing, cooking, eating or performing other domestic duties compared with men, while men may be performing more activities with a higher intensity level such as snow shoveling, wood cutting or heavy gardening than women [139]. In comparison, older men in the UK and in Iceland performed significantly more minutes of MVPA per day than women [43; 45], which is in agreement with our results that showed that men aged 75–79 years spent significantly more time in MVPA compared with women in the same age range.

Overall, 21% of the participants (18% and 22% for women and men, respectively) fulfilled the Norwegian physical activity recommendations [31]. Data from the UK showed a similar prevalence among older men (25.6% met national recommendations), but a lower prevalence among older women (14.2%) [43]. In the oldest age group, we found that only 6% reached the national physical activity recommendations. This is a higher percentage than reported in a study conducted in the UK by Harris et al. [44], which found that only 2.5% of the participants aged 65 years and older met the physical activity recommendations. Analyses based on the new Norwegian physical activity recommendations from 2014 [32] (minimum 150 minutes of moderate-intensity physical activity per week, or minimum 75 minutes of vigorous-intensity physical activity per week performed in bouts of at least 10 minutes), showed that 24.6% of the older adults aged ≥70 years (21.3% and 27.8% for women and men, respectively) fulfilled the national recommendations [140]. These results are slightly higher than the percentage who fulfilled the physical activity recommendations from 2004 [31], on which the results in **Paper I** are based.

Physical activity levels differed across levels of self-reported health, and a 51% higher overall level of physical activity was registered in those with “very good health” compared with those with “poor/very poor health”. One of the few available comparable studies targeting community-dwelling people in the UK aged 65 years and older showed that those with poor health took fewer steps compared with those with better health [44]. The study by Harris et al. [44] used a different method (Health Survey For England, 1988) to register self-reported health compared with our study, and therefore the degree of comparability is rather limited.

5.2 Musculoskeletal fitness and balance and its associations with physical activity levels in older adults (Paper II)

The results in **Paper II** show that the youngest participants (65–69 years) had significantly better static balance and muscular endurance in the trunk extensors compared with the older participants. Similar results have been found in one other study [83]. This finding might be related to differences in physical activity level across the age groups. In **Paper I**, we have shown a 50% higher activity level among the youngest participants (65–69 years) compared with the oldest participants (80–85 years). Another possible explanation might be that increasing age leads to a progressive loss of balance [6; 54; 55] and muscular strength and endurance [53], mostly because of degenerative processes in the central and peripheral nervous system [62], and qualitative and quantitative changes in the muscular system [54]. On the other hand, we were not able to show significant differences between the youngest (65–69 years) and the older age groups when it came to joint flexibility and handgrip strength, which have been observed in other studies [72; 73; 79; 80]. This discrepancy might be a result of cultural differences with respect to retirement age, infrastructure and degree of environmental security among the populations studied, as also mentioned above regarding differences in physical activity levels across countries (see 5.1).

Older Norwegian women (65–85 years) had significantly better mean upper- and lower-body flexibility compared with older men (65–85 years), which is in accordance with the findings from previous studies [72; 76; 85; 86]. A possible explanation for these sex-related differences might be related to differences in physical activity patterns among older men and women. In **Paper I**, we have shown that older Norwegian women spent more time (minutes) on low-intensity physical activity than did their male counterparts. This observation was confirmed in the present study because we found that women spent significantly more time each day performing low-intensity physical activity compared with men (216 versus 190 minutes, respectively; $p = 0.001$) (data not shown). We could therefore speculate whether daily low-intensity activities such as washing dishes, hanging washing, ironing and cooking might affect joint flexibility in older women by limiting the age- and activity-related deterioration. Other factors that might play a role regarding sex-related differences in joint flexibility are anatomical and physiological differences, smaller muscle mass and different joint geometry and collagenous muscle structure [164]. Furthermore, older Norwegian women also had significantly better muscular endurance in the trunk extensors compared with older men. This sex-related difference might be related to mechanical principles during the static back-extension testing. The shorter and lighter upper body of women compared with the longer and heavier upper body of men creates a shorter lever arm, resulting in a smaller torque in women than in men. This may make it easier for women to maintain the correct position for a longer period. In addition, women might be performing more domestic activities on a daily basis than men, as mentioned above, which requires them to stand in an upright position (e.g., when washing dishes, hanging washing, ironing and cooking). This might affect the muscular endurance capacity in their trunk extensors by limiting age- and activity-related deterioration. However, older Norwegian men had significantly better handgrip strength compared with women, which is in accordance with other cross-sectional studies where dynamometers were used [72; 79; 80; 81; 82]. However, no difference between the sexes was found in static balance, which is in contrast to one other study that showed significantly better static balance in older men than women [86]. A possible explanation for not finding any sex-related differences in the static balance among the older Norwegian adults might be related to their physical activity level. In **Paper I**, we have previously reported no sex-related differences in overall physical activity level within the different age groups among older Norwegian adults. This observation was confirmed in the present study, as we found no sex-related differences in the number of steps taken per day (7,551 for women versus 7,356 for men; p = 0.7) (data not shown).

A daily increment of 1,000 steps was associated with significantly better static balance and muscular endurance in the trunk extensors in older Norwegian individuals. A recently published study by de Melo et al. [75] reported that agility/balance was significantly associated with pedometer-assessed steps taken per day when comparing older Canadian adults categorized as “high walkers” (mean steps for 3 days ≥6,500) with “low walkers” (mean steps for 3 days <3,000). However, body sway/static balance was unrelated to accelerometer-defined measurements in older Japanese men and women [74]. In addition, handgrip strength was also unrelated to daily step counts in this elderly Japanese cohort, which is in line with our results. Furthermore, we found no association between a daily increase of 1,000 steps and upper- and lower-joint flexibility. In contrast, de Melo et al. [75] reported significantly better lower-body flexibility in “high walkers” than in “low walkers”. To our knowledge, no prior work has examined the association between muscular endurance in trunk extensors and physical activity among older adults, which makes our results rather novel.

5.3 Methodological aspects regarding measuring muscle strength and power in older adults (Paper III)

The results in **Paper III** show that the intraday reliability of the laboratory-based versions of CS and PILE tests was high. High test–retest reproducibility across trials could possibly be explained by the strict and standardized test protocol used in the present study. The intraday reliability of the field-based tests should be considered when evaluating this study, given that most researchers [99; 103; 123; 141; 142] have investigated the test-retest reproducibility across days rather than across trials.

The interday reliability of the field-based versions of CS and PILE tests was generally high. The range of scores on test days 1 and 2 was also similar for both field-based tests, supporting the finding of high test-retest reproducibility. Despite this, the 95% CIs were unacceptably wide for CS_{field}, which may be related to the relatively small sample size. Similar results have previously been reported by Jones et al. [99], who showed a nonsignificant change in scores from day 1 to day 2 (2-5-day interval), indicating that the field-based test had good reliability across days. Other studies have also concluded that the 30-s chair-stand test has good test-retest reliability across days in older adults [123; 141; 142]. Our $PILE_{field}$ interday reliability result was consistent with the findings of Mayer et al. [103], who found adequate test-retest reliability for the two-part lumbar and cervical version of the test. A similar result in the one-part (cervical only) lift was also found in the study by Horneij et al. [143]. As described in the Method section (see 3.3.5), we used one continuous lifting procedure in the PILE test, which is different to the original two-part lifting PILE test (a cervical and lumbar lift) used by others [103; 143]. Therefore, a comparison of the reliability is rather difficult. To our knowledge, no previous studies have examined the test-retest reliability of the PILE test using one continuous lift.

The interday reliability of the laboratory-based versions of CS and PILE tests was also considered generally high. The range of scores on test days 1 and 2 was quite similar for both laboratory-based tests, supporting the finding of high test-retest reproducibility. Despite this, the 95% CIs were unacceptably wide for $PILE_{lab}$, which may be related to the relatively small sample size.

A poor validity (low ICCs with unacceptable CIs) was revealed for the field-based versions of the chair-stand and box-lift tests. The lack of significant correlations between the field and the laboratory versions of the CS and PILE tests indicates that the field-based versions were not valid for assessing relationships between muscle strength and power among elderly individuals, even though the test procedures in both versions were performed “as fast as possible” with integrated movements involving several muscle groups and a strict routine to ensure the correct lifting strategy. The field-based versions of the chair-stand and the box-lift tests did not measure the same properties as the laboratory-based tests; i.e., their validity was poor. Thus, these tests do not seem to assess relationships between strength and power performance, and are most likely measures of muscle fatigue resistance. Thus, the field-based tests might be useful to examine the functional performance in elderly populations but cannot be considered surrogates for the laboratory-based tests. Therefore, they also cannot be considered valid tests for assessing relationships between strength and power. Several previous studies [99; 123; 144] have found good relationships between chair-stand performance and a laboratory-based measure using a nonfunctional 1RM leg-press test, which was designed to measure maximum muscle strength. Nonetheless, the leg-press exercise is dissimilar in its movement pattern to most ADLs, so the functional value of the leg-press test could not be clearly ascertained. One published study [124] used a force platform to measure power output during the 30-s chair-rise test in 14 older adults. They reported a significant correlation between the average power output during the chair rises and predicted power developed through equations based on body mass and the number of chair rises performed during the first 20 s of the 30-s trial. These results indicate that lower-body muscle power in older adults might be accurately evaluated using data from the initial 20 s of a simple 30-s CS test. Although there were similarities in the testing tool (e.g., the use of a force platform) in our study compared with the study by Smith et al. [124], differences in the testing procedures could explain the strong correlation detected by Smith et al. [124]. No studies were found that specifically examined the validity of the PILE test. However, a number of studies have used the test or compared PILE results with other measures (see review by Innes [145]).

5.4 Traditional versus functional strength training in older adults (Paper IV)

The main results in **Paper IV** show that there was no difference in the effect on functional power (sit-to-stand and box-lift power) and traditional maximal strength (maximal leg-press and bench-press strength) between the two training regimes, namely traditional machine-based strength training versus functional strength training. However, a significant difference in effect was seen in traditional upper-body power (bench-press power test) between the two intervention groups and the control group.

Because we could not detect any difference in functional power and traditional maximal strength between the two exercise groups (high power strength group: HPSG, functional strength group: FSG), we combined the subjects and compared them with the control group (CG) to increase statistical power. A significant improvement in sit-to-stand power was found in the combined intervention group (80.3 ± 184.7 W, equivalent to 11.9%) compared with the CG (–59.2 + 155.8 W, equivalent to –4.1%; p = 0.030). A significant improvement in maximal leg-press strength was also found in the combined intervention group (199.5 ± 194.4 N, equivalent to 20.2%) compared with CG (14.2 ± 123.7 N, equivalent to 4.3%; p = 0.001). These results show that strength training at high intensity and high velocity, per se, appears to have a substantial effect on both lower-body strength and functional performance in older individuals, which is in agreement with previous research [109; 112; 114; 146; 147]. Surprisingly, our results showed no significant increases in upper-body performance (maximal strength) when comparing the combined group with the CG. The lack of significant differences between the groups for upper-body maximal strength and performance might be explained by differences in the responses of men and women.

No significant increases were seen in HPSG and FSG compared with CG in functional lower-body power in the sit-to-stand power test. These results were not consistent with those of Henwood and Taaffe [109; 146] who found a significant improvement in chair-rise ability after a high-velocity resistance-training program. Their study had a low training specificity, involved only an 8-week intervention period and had a relatively small number of participants in the training group (n = 15), so their results might be related to the use of a combination of high-intensity and high-velocity movements. At least for the lower-body musculature, the use of separate high-intensity and high-velocity sessions might be more effective than consistently using a single-session design where the concentric phase is performed as rapidly as possible. This hypothesis should be tested in future research. The lack of functional lower-body power improvements in HPSG is probably because of the low training specificity. This is in agreement with Henwood and Taaffe [109], who found that the proportional change in functional strength was less than the change in traditional strength after higher-velocity, machine-based strength training.

Both HPSG and FSG significantly improved their functional upper-body power in the box-lift power test from pre- to postintervention, although this change was not significantly different from CG. These findings differ somewhat from those of Skelton et al. [108], who found no change in bag-lifting performance after functional strength training. De Vreede et al. [118] demonstrated that functional strength training had a significantly greater influence on ADLs than traditional strength training in a group of elderly subjects. This result might be explained by the high training specificity in the functional group and based on this, we should probably have prevented FSG from performing box lifting, as this test was too specific to the pre- and postintervention test.

Both intervention groups (HPSG, FSG) had significantly improved traditional maximal strength measured in the leg press compared with the CG. However, no significant differences in the magnitude of change were found in maximal bench-press strength between the groups after 11 weeks of training. Studies evaluating the effects of high-power strength training using exercise machines have shown positive results in both maximal upper- and lower-body strength [97; 109; 112; 114; 117; 120; 146; 147]. As mentioned above, differences in the responses of men and women might partially explain the lack of significant differences in the change of upper-body strength between the groups. We therefore reexamined the HPSG data, split by sex, and found a significant improvement in maximal bench-press strength in men (23.2% compared with 1.5% in CG, $p<0.02$) but not in women. Previous data [148] have shown that men have more skeletal-muscle mass than women do, and that these sex-related differences are greater in the upper body, which might be reflected in our results.

An important explanation for some of the traditional strength gains observed in our study is the specificity of the training, which also might explain the outcomes of the studies cited above. The participants in HPSG trained on the same machines on which they were tested. This might explain the outcome from the high-power strength training on the exercise machines. An interesting issue in this regard is the effect we found on traditional maximal lower-body strength (maximal leg-press strength) after 11 weeks of functional strength training. The FSG subjects did not train using the test exercises, resulting in a low training specificity. The stair-climbing activity with external load on the back might have elicited enough strength adaptation to result in the increases seen in traditional lower-body strength, even though the training exercise was unilateral and the testing was conducted bilaterally.

HPSG significantly improved bench-press power compared with both FSG and CG. These results are probably because of the high-intensity and high-velocity movements that HPSG subjects completed during the 11-week intervention. Unfortunately, to our knowledge, only one study [114] has demonstrated the effects of power training on upper-body power among the elderly. However, no significant changes were found in leg-press power in HPSG and FSG after 11 weeks of training, and no change was observed when the two training groups were combined; 2.3 ± 57.1 W (1.8%) compared with 39.4 ± 52.3 W (16.6%) for CG. On the other hand, Henwood et al. [147] demonstrated enhanced lower-body muscle power after a period of high-velocity resistance training, which might be explained by their longer intervention period of 24 weeks.

Overall, in our study, strength training using exercise machines produced a greater outcome in traditional strength and power tests compared with functional strength training. These findings might be explained by a better control of the speed of contraction (movement) and the greater training load used by the traditional strength-training group than by the functional strength-training group, despite the fact that both groups had the intention to work at both a high training intensity and a high training velocity.

5.5 Study design, selection bias and generalization

Papers I and **II** were based on a cross-sectional design, where the subjects performed the assessments at a single time point (phase one (2008–2009): physical activity assessments and phase two (2009–2010): musculoskeletal fitness and balance assessments). In any cross-sectional study, it is necessary to be cautious in inferring causality based on the findings. Furthermore, it is possible that confounders (e.g., marital status, health status, working versus nonworking) other than age, sex, BMI, education level, test center and daily accelerometer wear time might have affected the observed associations. The subjects included in **Papers I** and **II** were stratified according to sex, age and geographic place of residence, and were randomly selected for participation in the study. Thirty-one percent of the invited sample accepted the invitation concerning physical activity assessment. Overall, this is a relatively low participation rate. A dropout analysis performed in test phase one via registry linkage showed that the responses varied according to sociodemographic variables [122], which was consistent with other population-based studies conducted in Western countries [149]. The physical activity level, self-reported health, musculoskeletal fitness and balance variables presented in **Papers I** and **II** may be overestimated because of selection bias. The degree of generalization may therefore be questioned.

Paper III was based on a correlational research design where the purpose was to assess the relationship between two variables/data, and assess the direction and magnitude of the relationship. The fact that the participants were quite homogeneous (regarding physical activity level and health status) can be considered a strength of this study, because a small spread of data would have reduced the magnitude of the correlations. Because performances were compared within individuals, it is less likely that the participants' physical and functional levels explain the low validity found in this study. However, the uneven distribution of women compared with men might have influenced the results and could probably render generalization quite difficult. However, analysis of the ICCs, split by sex, revealed a similar picture in the validity of test performances among men and women.

Paper IV was based on a randomized trial research design where the subjects studied were randomized into two intervention groups and a nonrandomized control group, which is a limitation that is addressed later (see 5.6.2). However, there were no differences between the three groups at baseline, indicating homogeneous groups based on age, height, weight and BMI. The fact that five of 15 controls dropped out of the study (four for medical reasons and one because of a failure to complete the required number of testing sessions), makes the sample size in the CG small and might have influenced the results.

5.6 Study strengths and limitations

5.6.1 Strengths of the studies

The major strength of **Papers I** and **II** is the use of accelerometers to assess physical activity in a relatively large sample of older adults. An accelerometer is considered a valid, accurate and reliable measuring device of the amount, frequency and duration of physical activity [25; 150]. In particular, previous studies support the validity of the GT1M accelerometers for assessing physical activity among adults, including older adults [151]. The participants also showed good compliance with the protocol, and few datasets were lost because of insufficient wearing time or defective monitors. Furthermore, the combination of objectively measured physical activity with self-reported health status in older adults, as presented in **Paper I**, is rather novel. These variables have often been presented separately in other studies [18; 43; 49], and few studies [44] have objectively measured physical activity level and its association with general health among older individuals. Another strength of **Paper II** is the use of standardized musculoskeletal fitness and balance tests with high validity and reliability [100; 152; 165; 166].

The main strength of **Paper III** is the use of a strict test protocol. In addition, the tests used to measure lifting capacity (in one continuous lift) and the ability to rise from a chair, which are fundamental abilities for autonomy of the elderly, are highly portable and are cost-effective and simple methods, making them easy to implement in various testing environments. A lifting test performed from the ground to a higher level in one continuous movement has a high degree of integrated muscle recruitment, and the muscle recruitment strategies are quite similar to many ADLs. Based on these factors, a single continuous lifting test could be considered a more valid and functionally relevant test when compared with the two-part lifting test used by other researchers [103; 143].

The strengths of **Paper IV** are the use of randomized intervention groups, objective validated and reliable traditional tests, objective reliable functional tests and the high training compliance of the participants. Studies in the area of power training designed for the elderly have mostly focused on lower-body power [97; 109; 110; 113; 120]. Investigating the combination of high-intensity and high-velocity training and the effect on both traditional and functional muscle strength and power involving the upper and lower extremities, as carried out in our intervention study, is rather novel.

5.6.2 Limitations of the studies

We acknowledge several limitations in the present studies. One limitation of **Papers I** and **II** is the relatively low participation rate (see 5.5). Furthermore, there are limitations worth noting when interpreting the accelerometry data reported in **Papers I** and **II**. Accelerometers do not provide qualitative information on the type of physical activities being performed, and hip-mounted accelerometers underestimate upper-body movements and activities such as carrying heavy loads, weight training, swimming and cycling [18]. Nevertheless, accelerometers are sensitive to ambulatory activities such as walking. In **Paper I**, the participants reported walking as the most frequently performed activity during the measurement period, which decreases the likelihood that physical activity levels were underestimated [122]. Walking technique must also be taken into consideration because it can affect the validity of accelerometer step counts, especially in older individuals [18]. It appears that some accelerometers can undercount activity in individuals with a nonstandard gait (e.g., upper body angled forward and knees bent during walking), thereby underestimating the activity level in these individuals [153]. Furthermore, when interpreting accelerometer data, there is a possibility that the observed differences in physical activity may simply reflect differences in accelerometer wear time between groups. However, in **Papers I** and **II**, there were no significant differences between the sexes and between age groups in terms of the number of minutes of daily accelerometer wear time, and the samples were compliant with the accelerometer protocol with a mean wear time of 14.0 hours per day.

In the past, methods based on self-ratings of health have been questioned because of their obvious subjective bias [154; 155]. However, studies have shown that self-reporting instruments including simple measures of health and self-reported functioning in older persons have acceptable reliability and validity [156; 157]. Furthermore, because such assessments are inexpensive and easy to administer and interpret, self-reported health as presented in **Paper I** is a practical tool that is suitable for use in the clinical environment [158] and has become an important variable to assess the state of health in the older population [50; 159].

Another limitation of **Paper II** is that 10 test centers were involved in the data collection, and this might have influenced the reliability of the data. To minimize this limitation, a detailed test protocol together with posters illustrating the test procedures were developed, followed by a pilot study where all the tests were completed prior to commencing the main study. In addition, all of the test leaders at each test center were trained in the test protocol and procedures.

In **Paper III**, the 1RM isometric dead-lift test was used to establish the working load in the PILE_{lab} test, which means that a static (isometric) test was used to decide the load in a dynamic (isotonic) test, and might therefore be considered a limitation of this study. Nevertheless, the static maximum test was used for safety reasons (being easy to control for correct ergonomic principles), and because it used the same working position as the dynamic test, which would likely result in similar muscle recruitment patterns. It is also necessary to emphasize that there may be some methodological issues concerning how validity was determined by comparing performances in the two field-based tests (the number of unsupported chair-stand repetitions and the maximum load lifted in the box-lift test, respectively) with calculated average power in the laboratory-based versions (CS_{lab},

$PILE_{lab}$) using a force platform and linear encoder. However, we found the methods to be appropriate for the purpose of the study, which was to assess relationships between muscle strength and power in functional tests designed for elderly individuals.

The low number of controls, the use of a nonrandomized control group and a possible learning effect have to be addressed with respect to **Paper IV.** When we started the intervention, we intended to complete two testing sessions for both the traditional and the functional strength tests, as part of the baseline measures, to reduce a possible learning effect. Unfortunately, because of a limited ability to use the laboratories for testing, we were not able to complete more than one testing session for each test at the baseline. However, to reduce a possible learning effect and to ensure that all of the participants felt comfortable with the different tests, each participant was able to perform an additional attempt before the actual testing started.

Furthermore, the lack of significant findings between the two training regimes (HPSG versus FSG) for functional power and traditional maximal strength, as presented in **Paper IV**, may be related to the high variability (SD) of the changes. To minimize this variability, an even better control of the participants' training status, by measuring their physical fitness level, could have been carried out before inclusion in the study. However, during the recruitment phase of the study, the goal was to ensure that the participants were quite homogeneous according to their activity level and health status, based on their responses to a questionnaire. In addition, all participants were community-dwelling elderly individuals and were able to travel to the training facilities and return home without any assistance.

Other possible explanations for the lack of statistical significance presented in **Paper IV** are the training intensity and velocity, training volume and the duration of the intervention period. It may be possible that it is easier to control for correct intensity and velocity in a traditional strength-training regime compared with a functional strength-training regime. This may have resulted in different training volumes in the two intervention groups, even though the same training protocol

[109; 135] was used in the two training regimes. It may be that an 11-week intervention period was too short and that two sessions per week were too few. Both the duration and the frequency of training could be increased in future studies to provide a greater training stimulus. However, most previous studies have used twice-weekly training and an intervention period of 8–24 weeks [109; 120; 147].

5.7 Practical implications

Paper I is the first population-based study conducted in Norway with the aim of objectively assessing physical activity levels in older age groups. Our findings may help to better understand the physical activity levels of older adults, thereby helping to guide the development of the necessary physical activity interventions targeted at older adults in Norway. Based on our findings, there is a great need to increase physical activity levels among older Norwegian adults. Implementation of physical activity interventions, with a special focus on increasing physical activity levels of older community-dwelling adults, should therefore be prioritized in the future because regular physical activity is critically important for healthy aging.

Paper II is the first population-based study conducted in Norway aimed at objectively assessing physical activity levels and musculoskeletal fitness and balance capacities in older age groups. Our findings may help to better understand the musculoskeletal fitness and balance capacities of older men and women and the associations with physical activity levels, and may be of importance in establishing future preventive health strategies aiming at older community-dwelling adults. The focus should be placed on enhancing balance, joint flexibility and muscular strength and endurance, because these components have relevance to the performance of ADLs and through this to the maintenance of independence and improved quality of life.

Our findings in **Paper III** may be of importance in the future use and development of reliable field- and laboratory-based test procedures when measuring the ability to rise from a chair and lifting capacity in elderly individuals. Conducting laboratory-based test procedures in a functionally relevant way (sit-to-stand and box-lift power tests), as undertaken in our study, is rather novel and therefore might be of clinical importance when the goal is to measure functional power in older adults.

Our findings in **Paper IV** may help to better understand the adaptation of older adults to different strength-training regimes (traditional versus functional strength training), and these findings may be of importance in developing preventive health strategies aimed at older adults in the future. Investigating the combination of high-intensity and high-velocity training and the effect on both traditional and functional muscle strength and power involving the upper and lower extremities, as carried out in our intervention study, is novel.

5.8 Recommendations and future research

*Based on **Paper I***

- Efforts to increase the physical activity levels of older adults should be of high priority.
- Efforts should be made to reduce sedentary time and increase lifestyle physical activity and MVPA among older adults in general.
- Establishment of a new national strategy and action plans on physical activity aimed at Norwegian society in general and older adults in particular.
- Ongoing surveillance and monitoring of physical activity level in the older population are needed to help evaluate the impact of the Norwegian Government initiatives to promote physical activity.

The present study leads to different questions and therefore the need for future research. More research is needed to better understand the characteristics of the least physically active elderly and those who are most physically active (e.g., functional level, health status, motives for physical activity, former physical activity experience, preferred type of physical activity). It is also necessary to further investigate potential age- and sex-related differences where a large, representative sample of older adults is included. This would help guide the development of the necessary preventive health strategies, with a special focus on physical activity interventions targeted at older men and women on a national level.

Based on ***Paper II***

- Establishment of a national strategy and action plans on physical activity interventions, with a special focus on musculoskeletal fitness and balance aimed at older adults, are necessary to help Norwegian society in general and older adults in particular to better understand the importance of being physically active, in addition to obtaining improved knowledge of how to implement these actions.
- Ongoing surveillance and monitoring of musculoskeletal fitness and balance in the older population are needed to help evaluate the impact of the Norwegian Government initiatives to promote physical activity.

The present study leads to different questions and therefore the need for future research. Future research should look more carefully into the objective assessment of physical activity levels and the associations with a comprehensive picture of musculoskeletal fitness and balance variables (including muscular strength and endurance and joint flexibility of the upper and lower extremities, in addition to balance) in older adults, where a large, representative sample is included. It is also necessary to further investigate potential age- and sex-related differences. This would help guide the development of the necessary preventive health strategies, with a special focus on physical activity interventions targeted at older men and women on a national level.

Based on ***Paper III***

- The field- and laboratory-based versions of the chair-stand and box-lift tests may be of importance for the use and further development of reliable tests designed for the elderly, given that lifting capacity and the ability to rise from a chair are fundamental abilities for autonomy of the elderly.
- The field-based versions of the chair-stand and box-lift tests may not be valid for assessing relationships between muscle strength and power in the elderly.

The present study leads to different questions and therefore the need for future research. There is a need for the future development of reliable field- and laboratory-based test procedures when measuring the ability to rise from a chair and lifting capacity in elderly people. We believe that the use of a force platform to measure power output during chair rises, and a linear encoder and load cell to measure lifting-power capacity for validation purposes have functional value in the assessment of older adults and should therefore be investigated further. Given the importance of muscle power, compared with muscle strength, as a predictor of functional independence with increasing age, more research is therefore necessary to develop functional tests that can assess relationships between muscle strength and power performance in elderly populations. There is a need for additional studies in this area where a large sample size is required to increase the statistical power.

Based on ***Paper IV***

- An effort should be made to implement high-power strength training aimed at older adults.
- It is highly recommended that the Norwegian Government recognizes the importance of maintaining or enhancing muscle strength and power in the older age groups, resulting in financial support for strength and power interventions on a broad national level.

The present study leads to different questions and therefore the need for future research. Future research should investigate the effects of different power-training protocols to improve functional ability in the elderly, thereby defining the mechanisms underlying such adaptations and, in this way, to determine the most effective power-training regime. There is also a need for more research regarding sex-related differences in the responses to different strength- and power-training regimes, where a large sample size is required to increase the statistical power.

6. CONCLUSIONS

Based on the results presented in **Papers I-IV**, the following conclusions can be drawn.

- The physical activity levels among older adults living in Norway differed by age, where the oldest (80–85 years) displayed a 50% lower activity level compared with the youngest (65–69 years). No sex-related differences in overall physical activity level within each age group were observed. Overall, the older adults spent 66% of their time being sedentary, 24% in low-intensity physical activity, 7% in lifestyle physical activity and 3% in MVPA. Women spent more time in low-intensity physical activity and less time being sedentary and in MVPA compared with men. Physical activity differed across levels of self-reported health, and a 51% higher overall level of physical activity was registered in those with “very good health” compared with those with “poor/very poor health”.
- The youngest (65–69 years) individuals among older adults living in Norway had significantly better static balance and muscular endurance in the trunk extensors compared with the older age groups. Older Norwegian women (65-85 years) had significantly better upper- and lower-body flexibility, in addition to better muscular endurance in the trunk extensors, compared with older men (65–85 years). Older Norwegian men had significantly higher handgrip strength compared with older women. No sex-related differences were found in static balance. A daily increment of 1,000 steps was associated with significantly better static balance and muscular endurance in the trunk extensors in older Norwegian adults (65–85 years).
- A poor validity of the field-based versions of the chair-stand and box-lift tests was observed in elderly individuals. Field-based chair-stand and box-lift tests may therefore not be valid for assessing relationships between muscle strength and power in elderly people. The intraday reliability of the laboratory-based versions of the chair-stand and box-lift tests was high in elderly individuals. The interday reliability of both the field and laboratory versions of the tests was generally high in elderly individuals.
- No difference in the effects was revealed between traditional strength training with exercise machines and functional strength training on

functional power (sit-to-stand and box-lift power) and traditional maximal strength (maximal leg-press and bench-press strength) in older adults. Traditional strength training group significantly improved traditional upper-body power (bench-press power) compared with both functional strength training group and nontraining controls.

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RESEARCH ARTICLE **Open Access**

Accelerometer-determined physical activity and self-reported health in a population of older adults (65–85 years): a cross-sectional study

Hilde Lohne-Seiler[1,2*], Bjorge H Hansen[1], Elin Kolle[1] and Sigmund A Anderssen[1]

Abstract

Background: The link between physical activity (PA) and prevention of disease, maintenance of independence, and improved quality of life in older adults is supported by strong evidence. However, there is a lack of data on population levels in this regard, where PA level has been measured objectively. The main aims were therefore to assess the level of accelerometer-determined PA and to examine its associations with self-reported health in a population of Norwegian older adults (65–85 years).

Methods: This was a part of a national multicenter study. Participants for the initial study were randomly selected from the national population registry, and the current study included those of the initial sample aged 65–85 years. The ActiGraph GT1M accelerometer was used to measure PA for seven consecutive days. A questionnaire was used to register self-reported health. Univariate analysis of variance with Bonferroni adjustments were used for comparisons between multiple groups.

Results: A total of 560 participants had valid activity registrations. Mean age (SD) was 71.8 (5.6) years for women (n = 282) and 71.7 (5.2) years for men (n = 278). Overall PA level (cpm) differed considerably between the age groups where the oldest (80–85 y) displayed a 50% lower activity level compared to the youngest (65–70 y). No sex differences were observed in overall PA within each age group. Significantly more men spent time being sedentary (65–69 and 70–74 years) and achieved more minutes of moderate to vigorous PA (MVPA) (75–79 years) compared to women. Significantly more women (except for the oldest), spent more minutes of low-intensity PA compared to men. PA differed across levels of self-reported health and a 51% higher overall PA level was registered in those, with “very good health” compared to those with “poor/very poor health”.

Conclusion: Norwegian older adults PA levels differed by age. Overall, the elderly spent 66% of their time being sedentary and only 3% in MVPA. Twenty one percent of the participants fulfilled the current Norwegian PA recommendations. Overall PA levels were associated with self-reported health.

Keywords: Physical activity level, Self-reported health, Accelerometer, Older people

Background

Regular physical activity in older adults is critically important for healthy aging [1]. The link between regular physical activity and disease prevention, maintenance of independence and improved quality of life is supported by strong evidence [2,3]. However, there is a lack of knowledge on the physical activity levels and sedentary behavior among older people. Current knowledge is primarily based on studies using subjective assessment methods (e.g. questionnaires). Recalling physical activity is a complex cognitive task, and old adults are likely to have particular memory and recall skill limitations [4-6].

The introduction of accelerometers for objective assessment of physical activity allows for valid and reliable assessments of activity intensity, frequency, and duration [7,8]. Accelerometry is less prone to the recall and social desirability biases associated with self-report instruments [9]. Objective information on the physical activity levels

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* Correspondence: hilde.l.seiler@uia.no
[1] Norwegian School of Sport Sciences, Department of Sport Medicine, P.B. 4014 Ullevaal Stadion, 0806 Oslo, Norway
[2] University of Agder, Faculty of Health and Sport Sciences, Service Box 422, 4604 Kristiansand, Norway

and sedentary behavior has the potential to increase our understanding of physical activity in old age [3].

There are only a limited number of studies that have assessed physical activity using accelerometers in older adults. Most of these studies were completed in the USA [10-12], Canada [13] and the United Kingdom [14,15] and relatively few studies are anchored in the northern European countries [16-18]. Additionally, there is a lack of knowledge regarding physical activity levels in adults over 79 years of age [11,13,18].

The World Health Organization recommends that information on how individuals perceive their own health should be collected in population-based studies including older individuals [19]. Self-reported health status is considered as a sensitive measure of overall health in older adults, influenced by physical function, the presence of disease, the existence of disabilities, functional limitations, and the rate of aging [20]. It is viewed as a holistic measurement of health, reflecting both physical and mental health as well as well-being [21]. At present, few studies have examined physical activity level measured objectively in the elderly in combination with self-report instruments including simple measures of health [22].

The aims of the present study were therefore to describe the level of accelerometer-determined physical activity in a random national sample of Norwegian older adults (65–85 years), and secondary to investigate the associations between physical activity level and self-reported health.

Methods

Design

This study was part of a national multicenter study involving 10 test centers throughout Norway [23]. The sample included in this study is those aged 65 to 85 years (categorized into the age groups 65–69 years, 70–74 years, 75–79 years, and 80–85 years). From the Norwegian population registry a representative sample of 2040 individuals aged 65–85 years were drawn from the geographical areas surrounding the involved test centers, and study information and informed consent were distributed via mail to the drawn sample. Written informed consent was obtained from 628 subjects (313 women and 315 men, a total of 31% of the invited sample). Those with valid accelerometer data (accumulated at least 10 hours of valid activity recordings per day for at least four days) were included in the final data analysis (n = 560, 282 women and 278 men). The study was approved by the Regional Committee for Medical and Health Research Ethics and the Norwegian Social Science Data Services AS.

Measurement of physical activity

We used ActiGraph GT1M accelerometers (ActiGraph, LLC, Pensacola, FL) to measure the participants' physical activity levels [23]. The accelerometer registers vertical acceleration in units called counts, and collects data at a rate of 30 times per second in user-defined sampling intervals (epochs). The number of steps taken per day was registered using the embedded pedometer function. The participants received a pre-programmed accelerometer by mail. They were instructed to wear the accelerometer over the right hip in an elastic band while awake, and to remove the accelerometer when doing water activities. The participants wore the accelerometer for seven consecutive days, and they returned the accelerometer by prepaid express mail after the registration period.

We initialized and downloaded the accelerometers using ActiLife software provided by the manufacturer (ActiGraph LLC, Pensacola, FL). Customized SAS based macros (SAS Institute Inc., Cary, NC, USA) were used to reduce the data and derive the following variables: 1) mean counts per minute (cpm); 2) number of steps taken per day (spd); 3) number of minutes spent in intensity-specific categories, and 4) percentage of the study population meeting the national PA recommendations (minimum of 30 minutes of daily moderate PA in bouts of 10 minutes or more) [24]. The following intensity-specific cut-points were applied to the raw data; sedentary time was defined as all activity below 100 cpm (e.g. sitting, reclining, lying down) [25,26], low-intensity PA was defined as all activity between 100 and 759 cpm (e.g. washing dishes, hanging washing, ironing, cooking, eating, working at a computer desk or performing other office duties) [18], and time in lifestyle activity (e.g. slow walking, grocery shopping, vacuuming, child care) was defined as all activity between 760 and 2019 cpm [18,27]. Moderate-to-vigorous PA (MVPA) was defined as all activity ≥2020 cpm (e.g. walking at speeds of $\geq 78\ \mathrm{m \cdot min^{-1}}$ or more vigorous activities) [12]. The number of minutes per day at different intensities was determined by summing all minutes where the count met the criterion for the specific intensity, divided by the number of valid days.

Activity files were deemed valid if a participant accumulated at least 10 hours of valid activity recordings per day for at least four days, which is in accordance with the suggestions by Trost, McIver, and Pate [28]. Wear time was defined by subtracting non-wear time from 18 hours (all data between 00:00 and 06:00 were excluded). Non-wear time was defined as intervals of at least 60 consecutive minutes with zero counts, with allowance for 1 minute with counts greater than zero.

Other variables

The participants self-reported data on anthropometry (body height and body mass), level of education level and perceived health through a questionnaire. Body mass index (BMI) was computed as body mass (kg) divided by height in meters squared (m^2). Level of education was categorized into four groups: less than high school, high school, less than four years of university education, and university education for four years or more. Perceived health was reported as "very good health", "good health", "either good or bad health", and "poor/very poor health". Self-reported perceived health scale was condensed from five to four categories. "Very good health", "good health" and "either good or bad health" were kept in separate categories, while "poor health" and "very poor health" were combined into one category "poor/ very poor health". This was due to the low numbers in the "poor" and "very poor health" groups.

In addition, the participants also recorded if they were retired or in part-time/full-time employment.

Statistical analysis

All statistical analyses were conducted using IBM SPSS Statistics 19 for Windows (IBM Corporation, Route, Somers, NY, USA).

We assessed differences in continuous variables (age, height, body mass, BMI, number of minutes spent in intensity-specific categories) between women and men in the different age groups using Student's t-test for independent samples. We used Pearson's chi-square analyses to identity differences between the sexes in education level and self-reported health, and in the proportion of participants from each sex who adhered to the current PA recommendations.

Univariate analysis of variance with Bonferroni adjustments were used for comparisons between multiple groups. Overall physical activity level (cpm and spd) varied between test centers and with age, and these variables were therefore treated as potential confounders. When studying the differences in PA measurements (both cpm and time in different intensity categories) by age and sex the analysis were adjusted for test center (Tables 1 and 2).

Furthermore, BMI and education level varied across the categories of self-reported health, and thus treated as potential confounders. When examining the differences in overall PA levels in the different self-reported health groups, analysis were adjusted for test center, age, BMI, and education level (Figure 1). Linear regression analysis was used to estimate changes in physical activity level with increasing age.

Results

Physical characteristics of the study sample

Table 3 shows anthropometrical data, level of education and self-reported health of the study sample. The mean age (standard deviation (SD)) was 71.8 (5.6) years for women (n = 282) and 71.7 (5.2) years for men (n = 278). Overall, 34% of the participants reported an education level less than high school, 36% reported completing high school, and 30% reported to have a university education. The majority of the study sample reported having "very good health" (22.3% of women and 16.3% of men) or" good health" (56.2% of women and 53.7% of men). The majority (82%) of participants were retired whilst 11% were part time or full time employed. The remaining 6% didn't report their occupation. In the youngest age group (65–69 years) 73% were retired (4% didn`t report their occupation) compared to 96% in the oldest age group (80–85 years) (p < 0.01).

Table 1 Physical activity measurements by age and sex

	Women		Men		Mean difference	95% CI	All	
Age	N	Mean	N	Mean	(Men-Women)		N	Mean
Overall PA (cpm)[a, b]								
65–69 yr	127	311 (13.4)	116	325 (14.0)	14 (19.6)	−25 to 52	243	317 (9.2)[c]
70–74 yr	67	294 (19.2)	79	308 (17.7)	14 (26.1)	−38 to 65	146	301 (11.8)[d]
75–79 yr	51	215 (19.5)	55	256 (18.8)	41 (27.1)	−13 to 95	106	237 (13.9)[e]
80–85 yr	37	166 (11.2)	28	153 (12.8)	−13 (17.1)	−47 to 21	65	160 (17.7)[f]
Steps per day[a, b]								
65–69 yr	127	7537 (1825.1)	116	11191 (1886.5)	3654 (2646.5)	−1559 to 8867	243	9302 (866.1)[g]
70–74 yr	67	6904 (387.6)	79	6798 (353.0)	−106 (524.3)	−1143 to 930	146	6841 (1109.1)
75–79 yr	51	5256 (433.7)	55	6114 (417.9)	859 (602.8)	−336 to 2054	106	5721 (1307.5)
80–85 yr	37	4059 (305,9)	28	3436 (348.8)	−623 (464.3)	−1550 to 304	65	3777 (1635.4)[h]

[a] *Data are presented as mean standard error of the mean (SEM).*
[b] *All values (overall PA in cpm and in steps per day) are adjusted for test centre.*
[c] *65–69 yr compared to 75–79 yr p = 0.000, and 65–69 yr compared to 80–85 yr p = 0.000.*
[d] *70–74 yr compared to 75–79 yr p = 0.03, and 70–74 yr compared to 80–85 yr p = 0.000.*
[e] *75–79 yr compared to 65–69 yr p = 0.000, 75–79 yr compared to 70–74 yr p = 0.03, and 75–79 yr compared to 80–85 yr p = 0.04.*
[f] *80–85 yr compared to 65–69 yr p = 0.000, 80–85 yr compared to 70–74 yr p = 0.000, and 80–85 yr compared to 75–79 yr p = 0.04.*
[g] *65–69 yr compared to 80–85 yr p = 0.02.*
[h] *80–85 yr compared to 65-79 yr p=0.02.*
No significant differences between sex within age groups.

Physical activity measurements

A total of 560 participants had valid accelerometer data and were included in the analyses. There were no differences in anthropometrical data or level of education when comparing the participants who were included and those who were excluded (due to insufficient accelerometer wear time) from the final analysis. The participants achieved a mean of 6.6 days (SD 1.4) with valid activity recordings, and the mean wear time was 14.0 hours per day (SD 1.2). The PA variables (overall PA in cpm and steps per day across age and sex) are presented in Table 1.

Overall PA level across age

Overall physical activity level (cpm) was significantly different between the age groups, except between the age groups 65–69 and 70–74 years. This accounted for an overall PA level difference of 21% ($p = 0.003$) between the70-74 and 75–79 years age groups, and a 32% ($p = 0.004$) difference between the 75–79 and 80–85 years age groups. The oldest (80–85 years) participants displayed a 50% ($p < 0.001$) lower activity level compared to the youngest (65–70 years). When using the data to simulate a longitudinal trend, the regression analysis revealed that the decline was equivalent to a rate of 9 cpm (2.8%) per year ($B = -9.4$, $p < 0.001$, 95% confidence interval (CI): −7, −12). The oldest age group took on average 5525 steps per day less than the youngest age group ($p = 0.02$, 95% CI: 626 to 10426), a relative difference of 59%. When using the data to simulate a longitudinal trend, the step variable displayed a yearly decrease of 215 steps ($B = -215$, $p < 0.001$, 95% CI: −263, −168).

Overall PA level across sex

There were no significant differences in overall physical activity level (cpm) or steps taken per day between women and men within the different age groups (Table 1).

Mean minutes per day spent in the different activity categories

Table 2 presents the mean minutes the participants spent in the different activity categories per day. In the two youngest age groups, men spent more time being sedentary compared to women (558 vs. 535 min ($p = 0.02$) and 554 vs. 525 min ($p = 0.03$), respectively). Women in all age groups, except for the oldest, spent more minutes in low-intensity PA compared to men (223 vs. 192 min ($p < 0.001$), 223 vs. 187 min ($p < 0.001$) and 200 vs. 179 min ($p = 0.05$), for the 65–69, 70–74, 75–80 year age groups, respectively. No significant sex differences were found within age group when looking at the time spent in lifestyle activities. There was a decline in the proportion of time spent in MVPA when comparing the youngest age group with the oldest (34 vs. 9 min, $p < 0.001$). A difference between the sexes was only apparent in the 75-79-yr age group where men

Table 2 Mean ± SEM minutes per day[a] of sedentary activity, low PA, lifestyle PA, and MVPA

	Women (n = 282)		Men (n = 278)		Mean difference	95% CI	All (n = 560)	
Age	N	Mean ± SEM	N	Mean ± SEM	(Women-Men)		N	Mean ± SEM
Sedentary PA								
65–69 yr	127	535 (6.9)[b]	116	558 (7.3)	−23.1*	−42.9 to −3.3	243	547 (5.0)[e]
70–74 yr	67	525 (9.5)[c]	79	554 (8.7)	−28.9*	−54.4 to −3.5	146	541 (6.4)[f]
75–79 yr	51	561 (12.1)	55	580 (10.1)	−18.3	−49.6 to 13.0	106	571 (7.6)[g]
80–85 yr	37	592 (12.5)[d]	28	590 (11.5)	1.6	−32.3 to 35.6	65	591 (9.4)[h]
Low-intensity PA								
65–69 yr	127	223 (4.9)[i]	116	192 (4.4)[m]	30.9*	17.9 to 43.7	243	208 (3.5)[p]
70–74 yr	67	223 (6.4)[j]	79	187 (5.6)[n]	36.5*	19.7 to 53.3	146	203 (4.4)[q]
75–79 yr	51	200 (7.5)[k]	55	179 (7.6)	20.4*	−0.3 to 41.1	106	189 (5.2)[r]
80–85 yr	37	178 (8.6)[l]	28	157 (9.9[o])	21.4	−4.7 to 47.5	65	169 (6.5)[s]
Lifestyle PA								
65–69 yr	127	69 (3.2)[t]	116	67 (3.8)[x]	1.4	−8.4 to 11.2	243	68 (2.3)[bb]
70–74 yr	67	64 (5.0)[u]	79	65 (4.3)[y]	−1.6	−14.6 to 11.4	146	65 (3.0)[cc]
75–79 yr	51	49 (5.4)[v]	55	54 (4.9)[z]	−5.3	−19.7 to 9.1	106	52 (3.5)[dd]
80–85 yr	37	37 (3.6)[w]	28	31 (3.5)[aa]	5.3	−4.6 to 15.7	65	34 (4.3)[ee]
MVPA								
65–69 yr	127	32 (2.2)[ff]	116	36 (2.5)[jj]	−4.8	−11.4 to 1.9	243	34 (1.6)[nn]
70–74 yr	67	28 (3.0)[gg]	79	31 (2.9)[kk]	−2.6	−10.9 to 5.7	146	29 (2.0)[oo]

Table 2 Mean ± SEM minutes per day[a] of sedentary activity, low PA, lifestyle PA, and MVPA *(Continued)*

75–79 yr	51	17 (2.4)[hh]	55	27 (3.8)[ll]	−9.9*	−18.9 to −0.9	106	22 (2.4)[pp]
80–85 yr	37	10 (2.1)[ii]	28	9.0 (1.5)[mm]	1.3	−3.8 to 6.4	65	9 (2.9)[qq]

$p \leq 0.05$ for sex within age group.

[a] *All values (mean ± SEM minutes per day of sedentary activity, low PA, lifestyle PA, and MVPA) are adjusted for test centre.*

[b] *65–69 yr compared to 80–85 yr p = 0.001.*

[c] *70–74 yr compared to 80–85 yr p = 0.000.*

[d] *80–85 yr compared to 65–69 yr p = 0.001, 80–85 yr compared to 70–74 yr p = 0.000.*

[e] *65–69 yr compared to 75–79 yr p = 0.05, 65–69 yr compared to 80–85 yr p = 0.000.*

[f] *70–74 yr compared to75–79 yr p = 0.02, 70–74 yr compared to 80–85 yr p = 0.000.*

[g] *75–79 yr compared to 65–69 yr p = 0.05, 75–79 yr compared to 70–74 yr p = 0.02.*

[h] *80–85 yr compared to 65–69 yr p = 0.000, 80–85 yr compared to 70–74 yr p = 0.000.*

[1] *65–59 yr compared to 75–79 yr p = 0.05, 65–69 yr compared to 80–85 yr p = 0.000.*

[j] *70–74 yr compared to 80–85 yr p = 0.000.*

[k] *75–79 yr compared to 65–69 yr p = 0.05.*

[l] *80–85 yr compared to 65–69 yr p = 0.000, 80–85 yr compared to 70–74 yr p = 0.000.*

[m] *65–69 yr compared to 80–85 yr p = 0.006.*

[n] *70–74 yr compared to 80–85 yr p = 0.04.*

[o] *80–85 yr compared to 65–69 yr p = 0.006, 80–85 yr compared to 70–74 yr p = 0.04.*

[p] *65–69 yr compared to 75–79 yr p = 0.02, 65–69 yr compared to 80–85 yr p = 0.000.*

[q] *70–74 yr compared to 80–85 yr p = 0.000.*

[r] *75–79 yr compared to 65–69 yr p = 0.02.*

[s] *80–85 yr compared to 65–69 yr p = 0.000, 80–85 yr compared to 70–75 yr p = 0.000.*

[t] *65–69 yr compared to 75–79 yr p = 0.005, 65–69 yr compared to 80–85 yr p = 0.000.*

[u] *70–74 yr compared to 80–85 yr p = 0.001.*

[v] *75–79 yr compared to 65–69 yr p = 0.005.*

[w] *80–85 yr compared to 65–69 yr p = 0.000, 80–85 yr compared to 70–74 y p = 0.001.*

[x] *65–69 yr compared to 80–85 yr p = 0.000.*

[y] *70–74 yr compared to 80–85 yr p = 0.000.*

[z] *75–79 yr compared to 80–85 yr p = 0.04.*

[aa] *80–85 yr compared to 65–69 yr p = 0.000, 80–85 yr compared to 70–74 yr p = 0.000, 80–85 yr compared to 75–79 yr p = 0.04.*

[bb] *65–69 yr compared to 75–79 yr p = 0.001, 65–69 yr compared to 80–85 yr p = 0.000.*

[cc] *70–74 yr compared to 75–79 yr p = 0.04, 70–74 yr compared to 80–85 yr p = 0.000.*

[dd] *75–79 yr compared to 65–69 yr p = 0.001, 75–79 yr compared to 70–74 yr p = 0.04, 75–79 yr compared to 80–85 yr p = 0.008.*

[ee] *80–85 yr compared to 65–69 yr p = 0.000, 80–85 yr compared to 70–74 yr p = 0.000, 80–85 yr compared to 75–79 yr p = 0.008.*

[ff] *65–69 yr compared to 75–79 yr p = 0.001, 65–69 yr compared to 80–85 yr p = 0.000.*

[gg] *70–74 yr compared to 75–79 yr p = 0.05, 70–74 yr compared to 80–85 yr p = 0.001.*

[hh] *75–79 yr compared to 65–69 yr p = 0.001, 75–79 yr compared to 70–74 yr p = 0.05.*

[ii] *80–85 yr compared to 65–69 yr p = 0.000, 80–85 yr compared to 70–74 yr p = 0.001.*

[jj] *65–69 yr compared to 80–85 yr p = 0.000.*

[kk] *70–74 yr compared to 80–85 yr p = 0.001.*

[ll] *75–79 yr compared to 80–85 yr p = 0.01.*

[mm] *80–85 yr compared to 65–69 yr p = 0.000, 80–85 yr compared to 70–74 yr p = 0.001, 80–85 yr compared to 75–79 yr p = 0.01.*

[nn] *65–69 yr compared to 75–79 yr p = 0.000, 65–69 yr compared to 80–85 yr p = 0.000.*

[oo] *70–74 yr compared to 80–85 yr p = 0.000.*

[pp] *75–79 yr compared to 65–69 yr p = 0.000, 75–79 yr compared to 80–85 yr p = 0.004.*

[qq] *80–85 yr compared to 65–69 yr p = 0.000, 80–85 yr compared to 70–74 yr p = 0.000, 80–85 yr compared to 75–79 yr p = 0.004.*

spent significantly more time in MVPA compared with women. Of the waking hours per day, the whole sample spent 9.3 hours (66%) being sedentary, 3.3 hours (24%) in low-intensity PA, 1 hour (7%) in lifestyle PA, and 30 minutes (3%) in MVPA.

Adherence to the physical activity recommendations

A total of 21% of the participants fulfilled the current Norwegian PA recommendations of 30 minutes of daily moderate physical activity, accumulated in bouts of 10 minutes or more (Table 4). The adherence to the recommendations decreased markedly with increasing age and among the 80–85 year-olds 6% adhered to the recommendations. A difference between the sexes were only observed in the 75-79-yr group where men had a significant higher adherence to physical activity recommendations than women (p = 0.01).

Overall PA levels and self-reported health

Physical activity levels differed across categories of self-reported health (Figure 1). Those reporting "very good health" had a 51% higher cpm compared to those in the "poor/very poor health" category (344 (13) vs. 170 (33) cpm, respectively ($p < 0.001$)), and those reporting to have "good health" had a 43.3% higher cpm compared to those reporting "poor/very poor health" (300 (8) vs. 170 (33) cpm, respectively (p = 0.001)).

Discussion

The main findings of the present study were that objectively-measured physical activity level significantly differed by age in a national sample of older adults. There were no sex differences in physical activity level within each age group. In the age groups 65–69 years and 70–74 years, men had higher levels of sedentary minutes than women, whilst men in the age group

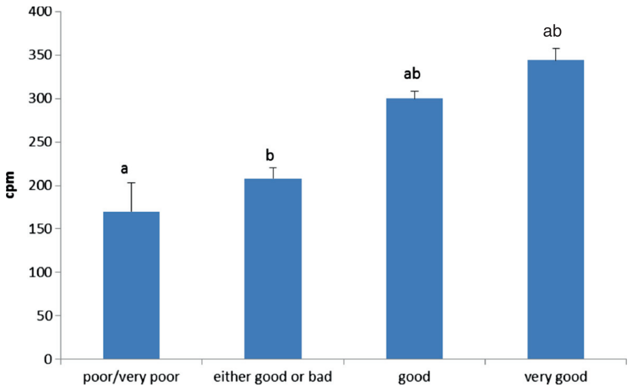

Figure 1 Mean (SEM) overall PA levels in counts per minute (cpm) in the different self-reported health groups ("poor/very poor health", "either good or bad health", "good health", and "very good health"). *a-b: Equal letter indicate significant difference (p<0.05) in overall PA level between the different self-reported health groups. All values are adjusted for age, BMI, education level, and test centre.*

75–79 years achieved more minutes of MVPA than women. In all age groups, except for the oldest one, women spent significantly more minutes of low-intensity PA than men. Also, overall physical activity was associated with self-reported health.

We found that accelerometer-determined physical activity significantly differed between the different age groups, with the oldest age group having substantially lower mean physical activity levels than the youngest age group. This is in accordance with other cross-sectional studies using the same objective method [10-17]. Our population appeared to have somewhat higher overall physical activity level than what has been reported in other studies [12,16]. While Norwegian men and women in age group 75–79 years had a mean cpm of 256 and 215, respectively, data from this age group in Iceland showed lower physical activity levels (mean cpm 150 and 139 for men and women, respectively) [16]. Our mean physical activity levels in individuals aged 65–74 years are higher than what has been reported among Americans [12]. However, the activity levels in Norway are similar to what has been reported in Sweden [17]. This might be

Table 3 Physical characteristics, education level, and self-reported health of the study sample (n = 560) by age and sex

	65–69 yr		70–74 yr		75–79 yr		80–85 yr		All	
Variable	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men
N	127	116	67	79	51	55	37	28	282	278
Age (yr)[a]									71.8 (5.6)	71.7 (5.2)
Height (cm)[a]	164.1 (5.4)	178.1 (5.9)*	163.4 (5.1)	177.1 (6.8)*	163.3 (5.0)	175.9 (8.5)*	163.8 (6.3)	175.4 (5.0)*	163.8 (5.4)	177.1 (6.7)*
Body mass (kg)[a]	67.8 (10.5)	84.7 (11.5)*	65.5 (10.4)	80.0 (11.9)*	63.4 (7.5)	77.2 (11.2)*	67.4 (11.1)	76.1 (10.5)*	66.4 (10.2)	81.0 (11.9)*
BMI (kg/m^2)[a]	25.1 (3.7)	26.7 (3.0)*	24.5 (3.9)	25.4 (3.2)	23.8 (2.6)	25.0 (3.2)*	25.1 (3.5)	24.7 (2.9)	24.7 (3.6)	25.8 (3.2)*
Education level (%)										
Less than high school	38.8	28.1	37.3	38.0	42.0	25.9	26.8	38.7	37.3	31.6
High school	35.7	35.5	41.8	31.6	32.0	40.7	34.1	38.7	36.2	35.8
University <4 yr	10.9	20.7	11.9	20.3	20.0	16.7	24.4	9.7	14.6	18.6
University ≥4 yr	14.7	15.7	9.0	10.1	6.0	16.7	14.6	12.9	11.8	14.0
Self-reported health (%)										
Very good	22.3	16.3	20.9	23.5	9.8	10.9	14.3	18.8	18.6	17.5
Good	56.2	53.7	56.7	49.4	62.7	54.5	45.2	40.6	55.9	51.2
Either good or bad	19.2	27.6	19.4	27.2	23.5	27.3	31.0	31.3	21.7	27.8
Poor/very poor	2.3	2.4	3.0	0.0	3.9	7.3	9.5	9.4	3.8	3.4

[a]*Data are presented as mean (SD).*
**p < 0.05 between sex within age group and all.*

due to differences in socioeconomic status, cultural differences with respect to retirement age, infrastructure and degree of environmental security among the populations studied.

We did not find significant sex differences in physical activity level within each age group, which is in contrast with similar studies from other countries usually showing a higher mean physical activity level among men than among women [10,11,13-16]. This discrepancy might be connected to cultural differences as described above. Also, the lack of a difference in PA level between sexes in the present study is also in contrast to earlier Norwegian studies using self-reported measures of PA [29]. Women may spend more time doing low and lifestyle intensity activities, such as walking, household chores, and gardening [14]. Subjectively-assessed PA have limited accuracy at capturing activities that are unstructured and of low intensity [4], which have a tendency to be performed more often in older populations and in particular among older women [30-32]. This is supported by the fact that Norwegian women spent more time in low-intensity PA and have less sedentary time compared to their male counterparts.

The participants spent the majority of the day being sedentary (66% of the total wear time), and this was followed by low-intensity PA (24%), lifestyle PA (7.1%) and MVPA (3.0%). These findings are comparable to what has been reported among older adults in Iceland [16], Great Britain [14], and Canada [13]. Resent research has also shown dose–response associations between sitting time and mortality from all causes, independent of leisure time physical activity [33]. The large proportion of sedentary time and increased sitting-time is worrying as it might lead to substantial health problems for older people and as a consequence, reduced quality of life and need for assistance. It is therefore important to develop and initiate interventions where the goal is to increase physical activity levels and reduce sedentary time among older adults. In addition to the PA promotion, physicians should also discourage sitting time for extended periods.

When looking at sex- and age trends, Norwegian women are spending less time being sedentary and more time in low-intensity PA per day compared to men at the same age as mentioned above, while men (75-79-yr age group) accumulate more minutes of MVPA than women. In comparison, older men in the UK performed significantly more minutes of MVPA per day than women (23.1 vs. 13.8 min) [14]. Furthermore, the British older adults had a steep decline in the proportion of active time spent in MVPA with increasing age [14], which is in accordance with our results. Similar patterns are also observed among US older adults [10] and among Canadians aged 20–79 years [13], where MVPA decreased across increasing age [10].

Table 4 Percentage of the population meeting current PA recommendations

	Women	Men	All
≥30 min of daily MVPA, in bouts of 10 min or more			
Age			
65–69 yr	25.0	29.0	27.9[b,c]
70–74 yr	20.3	19.5	19.9
75–79 yr	5.8	22.8[a]	14.8[d]
80–85 yr	7.1	3.0	5.6[e]

[a] *p = 0.01 for sex within age group.*
[b] *65-69 yr compared to 75–79 yr p = 0.02.*
[c] *65-69 yr compared to 80–85 yr p = 0.000.*
[d] *75-79 yr compared to 65–69 yr p = 0.02.*
[e] *80-85 yr compared to 65–69 yr p = 0.000.*

The age group 65–69 years averaged 5525 steps more per day than the individuals in age group 80–85 year (p = 0.02), a relative difference of 59%. This is in accordance to what has been found in two other studies [14,15] including older adults, both using accelerometer to assess PA levels. Davis et al. [14] found that younger participants (70–75 years) averaged significantly more steps per day (5661 steps per day) than participants aged 80+ years (3410 steps per day). Harries et al. [15] also showed that step-count declined steadily with age. In the latter study, however, sex differences in step counts were also reported and men achieved 754 more steps daily than women. This is in contrast to the result of the present study where no sex differences in step counts were reported.

Overall, 21% of the participants (women and men: 18% and 22%, respectively) fulfilled the current Norwegian PA recommendations. Data from the United Kingdom shows a similar prevalence among older men (25.6% met national recommendations), but a lower prevalence among older women (14.2%) [14]. In the oldest age group, we found that only 6% reached the national physical activity recommendations. This is a higher percentage compared with a study conducted in the United Kingdom by Harris et al. [15], showing that only 2.5% of the participants 65 years and older met the PA recommendations. On the other hand, looking at the Icelandic oldest (85 years and older), as much as 25% of the men and 9% of the women fulfilled the recommendations, defined as having at least one ≥10 minutes MVPA boats [16]. However, comparability between the current study and the Iceland study [16] is hampered by the use of different physical activity recommendation criteria and differences in data reduction strategies.

In Norway, mean physical activity level declines by approximately 30% between the ages of 9 and 15 years [34]. A further decline of 30% for women and 35% for men have been observed when going from 15 years into adulthood, followed by a stable level of activity until retirement age [23]. Following retirement to 80–85 years, a further decline of 47% in women and 53% in mean PA level was observed in the present study. The causes for these age-related changes in physical activity level are not fully known, although the overall decline of 50% observed during the age of being 65 years to entering 85 years, might be caused by changes in health status and of course the aging process in itself [35]. The higher mean physical activity level in the youngest age group might also be explained by higher prevalence of participants in this age group reporting part- or full time employment than participants in the oldest age group (23% versus 4%). 23% of the youngest age group still reported the fact to be employed. For example, if their work involves a lot of walking and their physical activity measurement period includes only working days then their measured activity level may be higher compared to someone whose measurement period includes non-working days where they may be less active. This will overall affect their computed average activity levels, and has to be taken into consideration.

In the present study significant differences in the overall level of PA were observed between all self-reported health groups, except between those who perceived their health as “either good or bad” and “poor/very poor health”. One of few available studies mentioned above is targeting community-dwelling people in the U.K. from 65 years and older showed that those with poor health took fewer steps compared to those with better health [15]. This difference ($p > 0.05$) was not found in the current study (data not shown). The latter study used a different method (Health Survey form England, 1988: questions related to general health, disability, long-standing illness, pain, medication use, chronic disease, falls, and walking aid use) to register self-reported health compared to the this study and therefore, the degree of comparability is rather limited. The associations between physical activity level and perceived health are strong, but due to the study design we cannot determine causality.

The major strength of this study is the use of accelerometers to assess physical activity in a relatively large sample of older adults. The participants showed good compliance with the protocol and few data were lost because of insufficient wearing time or defect monitors. Objectively-measured physical activity in combination with self-reported health in older adults, is rather novel. These variables are often presented separately in other studies [11,14,21], and few studies [15] have objectively measured physical activity levels and its association with multiple health factors (e.g. general health).

We acknowledge some limitations to our study. One limitation is the relatively low participation rate. A drop-out analysis performed via registry linkage showed that the responses varied according to socio-demographic variables [23], which is consistent with other population-based studies conducted in Western countries [36].

Furthermore, there are limitations worth noting when interpreting accelerometry data [11]. Accelerometers do not provide qualitative information on the type of physical activities being performed, and hip-mounted accelerometers underestimate upper body movements and activities such as carrying heavy loads, weight training, swimming, and cycling [11]. Nevertheless, accelerometers are sensitive to ambulatory activities such as walking. The participants reported walking as the most frequently performed activity during the measuring period, which decreases the possibility that physical activity level was underestimated [23]. Walking technique must also be taken into consideration because it can affect the validity of accelerometer counts, especially in older individuals [11]. It seems that some accelerometers can undercount activity in individuals with a non-standard gait, e.g. upper body leaned forward and bended knees during walking, thereby underestimate the activity level in these individuals [37]. Furthermore, when interpreting accelerometer data, there is a possibility that the observed differences in physical activity may simply reflect differences in accelerometer wear time between groups. However, there were no significant differences between sexes and between age groups in minutes of daily accelerometer wear time and the sample were compliant to the accelerometer protocol with a mean wear time of 14.0 hours per day.

In the past, methods based on self-ratings of health have been questioned because of their obvious subjective bias [5,6]. Self-reported height and body mass is therefore considered as a limitation to our study. However, several studies have shown that self-report instruments concluding simple measures of health and self-reported functioning in old persons have acceptable reliability and validity [38,39]. Furthermore, because it is inexpensive and easy to administer and interpret, self-reported health is a practical tool suitable for the clinical environment [40] and has become an important variable to assess the state of health in the older population [20,41].

Our findings help to better understand older peoples' rate of physical activity and thereby help guide the development of needed physical activity interventions targeted at older adults in Norway. The link between PA and prevention of disease, maintenance of independence and improved quality of life in older adults is supported by strong evidence [2,3], and therefore it is of great importance to maintain PA levels as long as possible. Implementation of PA among community-dwelling older adults should therefore be prioritized in the future, with a special focus on the least physically active and the oldest individuals, especially in those with low levels of self-reported health.

Conclusion

Physical activity level among older adults living in Norway differ by age, where the oldest (80–85 years) displayed a 50% lower activity level compared to the youngest (65–70 years). No sex differences in overall PA level within each age group were observed. Overall, the older people spent 66% of their time being sedentary, 24% in low-intensity PA, 7% in lifestyle PA, and 3% in MVPA. Women spent more time in low-intensity PA, and less time being sedentary and in MVPA compared to men. Overall, 21% of the participants fulfilled the current Norwegian PA recommendations. In the oldest age group, 6% met the recommendations. Physical activity differed across levels of self-reported health and a 51% higher overall level of physical activity was registered in those with "very good health" compared to those with "poor/very poor health. Overall PA levels were associated with self-reported health.

Abbreviations

CI: Confidence interval; MVPA: Moderate to vigorous physical activity; PA: Physical activity; SD: Standard deviation; SEM: Standard error of the mean.

Competing interests

The authors declare that they have no competing interests. The results of the present study do not constitute endorsement by the BMC Public Health.

Authors' contributions

SAA contributed to the conception and design of the study. BHH was responsible for the collection of the KAN data in corporations with colleagues at nine other test centers throughout Norway. BHH provided the data for analysis. HLS undertook the data analysis and drafted the manuscript. All authors provided critical insight, and revisions to the manuscript. All authors read and approved the final version of the manuscript submitted for publication.

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PAPER II

Musculoskeletal fitness and balance in older individuals (65-85 years) and its association with steps per day: a cross sectional study.

H. Lohne-Seiler[1,2]*§, E. Kolle[2]*, S.A. Anderssen[2]*, B.H. Hansen[2]*

[1] *Faculty of Health and Sport Sciences, University of Agder, Kristiansand, Norway,*

[2]*Department of Sport Medicine, Norwegian School of Sport Sciences, Oslo, Norway*

Running head: Musculoskeletal fitness, balance, and physical activity level.

Corresponding author:

Hilde Lohne-Seiler. University of Agder, Faculty of Health and Sport Sciences,

Service Box 422, N-4604 Kristiansand, Norway.

Phone: + Int 47 38 14 12 89,

E-mail: hilde.l.seiler@uia.no

*These authors contributed equally to this work

§Corresponding author

E-mail addresses:

Hilde Lohne-Seiler hilde.l.seiler@uia.no

Elin Kolle Elin.Kolle@nih.no

Sigmund Alfred Anderssen s.a.anderssen@nih.no

Bjorge Herman Hansen b.h.hansen@nih.no

Abstract

Background

There is limited data on population levels including musculoskeletal fitness (MSF), balance and physical activity (PA) among older adults using objective assessment methods. The aims were therefore to; 1) describe MSF and balance in older Norwegian adults; 2) examine age- and sex-related differences in MSF and balance; 3) investigate the association between MSF- and balance with objectively-assessed PA levels.

Methods

This was part of a national multicenter study. Participants (65-85 years) were randomly selected from the national population registry. We used ActiGraph GT1M accelerometers to measure PA. Balance and MSF were assessed using: one leg standing (OLS), hand grip strength (HG), static back extension (SBE), sit and reach (SR), back scratch right and left arm over (BSR, BSL). Univariate analyses of variance were used to assess sex differences within the different tests and for comparisons between multiple age groups. Linear regression analysis was used to investigate how PA was associated with MSF- and balance.

Results

85 women and 76 men were included. Mean age (standard deviation (SD)) was 73.2 (5.4) years for women and 72.3 (4.8) years for men. The youngest participants (65-69 years) had significantly better mean OLS- and SBE results compared with the older participants. Women (65-85 years) had significantly better mean SR, BSR, BSL and SBE results compared with men (65-85 years). Men had significantly better mean HG results compared with women. No sex differences in mean OLS results were observed. A daily increment of 1,000 steps was

associated with better mean test scores for OLS- and SBE tests (b=1.88, 95% CI: 0.85 to 2.90 (p≤0.001) and b=4.63, 95% CI: 1.98 to 7.29 (p=0.001), respectively).

Conclusion

The youngest (65-69 years) had better static balance and muscular endurance in trunk extensors compared with the older participants. Older women (65-85 years) had better joint flexibility than older men (65-85 years), whereas older men had better handgrip strength than older women. A higher PA level was associated with better static balance and muscular endurance in trunk extensors in older individuals. Our results may be of importance towards establishing future preventive health strategies among older men and women.

Key words: accelerometer-determined physical activity, fitness score, older people.

Background

Increasing age leads to a progressive loss of muscular strength, muscular endurance, joint flexibility [1], and balance [2, 3, 4]. Age-induced musculoskeletal fitness (MSF; a comprehensive picture of upper- and lower body muscular strength and muscular endurance, and upper- and lower body joint flexibility) loss may inhibit older people from performing basic functional tasks such as lifting and moving objects, rising from a chair, and walking, and is therefore of great importance for a persons` capability to manage daily life activities and to maintain functional independence [5, 6, 7]. The incidence of falls increases with age where muscle weakness, impaired gait and diminished balance are the most significant risk factors for falling [8, 9]. Managing daily life activities are based on the individuals balance capability, meaning the ability to maintain the body`s position over its base of support whether it is a moving (dynamic balance) or stationary base (static balance) [8]. Static balance might therefore be an important component for predicting falls in older adults [49]. . Balance- and muscle strengthening activities, seems to influence risk factors for falls by increasing muscle strength and balance ability [54, 55], which is of great importance in order to keep older adults independent in daily life longer [54].

However, there is limited MSF- and balance data on population levels among older men and women where standardized-assessment methods have been used [10, 11]. Current knowledge is primarily based on studies that have measured balance [12], or handgrip strength [13, 14, 15, 16] separately. Few published studies have focused on an overall fitness evaluation (i.e. a more comprehensive picture of MSF and balance) among older adults [17, 18]. These studies showed that all test scores declined with increasing age. Women scored better on the upper and lower body flexibility tests, whereas men performed better on upper and lower body strength- and balance tests [17, 18]. The majority of the population-based studies mentioned above have all been conducted outside the Nordic countries. In Norway, population-based MSF- and balance data of individuals 65 years and older have not yet been published.

Physical activity (PA) levels decline significantly with age [19, 20, 21, 22, 23, 24]. In older individuals, loss of MSF and balance in combination with decreased PA levels is strongly predictive to falls [25], disability [26], hospitalization [27], reduced quality of life [28], and increased mortality [1, 29]. There are a limited number of studies assessing the association between MSF level, balance ability and objectively assessed PA levels in older adults. Also, some of the existing studies showed an association between MSF, balance and PA levels [31, 32, 33, 34], whereas others did not [8, 30]. It is also somewhat difficult to distinguish which components of MSF (i.e. muscle strength and endurance, and joint flexibility) might be associated with PA level in the studies mentioned above. A study conducted by Aoyagi et al. [30] showed that balance and handgrip strength were both unrelated to daily step counts, whereas lower-extremity function (walking speeds and knee extension torque) was positively related to daily step counts in older adults. A study conducted by de Melo et al. [31] showed that balance and lower body flexibility were both associated with daily step counts in older adults (mean steps for 3 days: ≥ 6500).

Regular physical activity in older adults is associated with improved functional ability [56], maintaining mobility [58], and inversely related to mortality [57]. Therefore, more knowledge about musculoskeletal fitness- and balance ability in older men and women, and their association with physical activity level, may be of importance towards establishing future preventive health strategies in older adults.

Given these considerations, the aims of the present study were to; 1) describe musculoskeletal fitness and balance in a random national sample of Norwegian older individuals (65-85 years); 2) examine age- and sex-related differences in musculoskeletal fitness and balance, and 3) to investigate the association between musculoskeletal fitness- and balance with objectively-assessed physical activity levels.

Methods

Design and participants

This study was part of a national multicenter study involving 10 test centers throughout Norway [23, 24], and consisted of test phase one (determining physical activity level using accelerometers) and phase two (determining MSF level and balance). A representative sample of 2040 individuals aged 65-85 years, were drawn from the Norwegian population registry. The participants were randomly selected and stratified based on sex, age and geographical place of residence. Study information and informed consent were distributed via mail to the drawn sample. Written informed consent was obtained from 628 participants (313 women and 315 men, a total of 31% of the invited sample), and they all went through accelerometer registration. Those with valid accelerometer data (accumulated at least 10 hours of valid activity recordings per day for at least four days) were included in the data analysis (n=560, 282 women and 278 men) in test phase one. Due to limited capacity at the 10 test centers performing the MSF- and balance testing a total of 30 % of those participating in test phase one was invited to participate in test phase two to assess MSF level and balance. The subjects invited to test phase two were randomly selected and stratified based on sex, age and geographical place of residence. . The participants with both valid accelerometer-determined data and MSF- and balance measurements (described below) were included in the final data analysis (n=161, 85 women and 76 men).

The study was approved by the Regional Committee for Medical and Health Research Ethics and the Norwegian Social Science Data Services AS.

Measurement of musculoskeletal fitness and balance

The MSF- and balance test battery in the present study is partly based on the ALPHA (Assessing Levels of Physical Activity and Fitness) group recommendation by Suni et al. [35], and includes the following tests; one leg standing [36], handgrip strength [37], and static back extension [59]. These established field based tests aiming at adults and older adults, were given a score by the ALPHA group [35] from 0-12 points (where 12 was the best) based on the validity, reliability, safety and feasibility, and the result was as follows; 9 points to the one leg standing test [36], 7 points to the handgrip strength test [37], and 9 points to the static back extension test [59].

The MSF- and balance test battery in the present study also includes tests measuring upper- and lower body flexibility, since the degree of joint flexibility seems to be related to overcome daily life activities, especially among the older adults [39]. These tests are; sit and reach [38] and back scratch [39]. The sit and reach test has been demonstrated by Lemmink et al. [61] to produce reliable scores from test session-to-test session measuring the flexibility of hamstrings and lower back in older women and men (intraclass correlations (ICCs): 0.96, 95% confidence interval (CI): 0.94 to 0.97 and ICCs: 0.98, 95% CI: 0.97 to 0.99, respectively). The sit and reach test has also been shown to be a valid measure of hamstring flexibility in older women and men (ICCs: 0.57, 95% CI: 0.39 to 0.71 and ICCs: 0.74, 95% CI: 0.58 to 0.85, respectively) [62]. The back scratch test has been demonstrated by Rikli and Jones [39] to be a reliable (ICCs: 0.96, 95% CI: 0.94 to 0.98) and valid (no single criterion available) measure of overall shoulder range of motion (i.e. shoulder joint- and arch flexibility) in older adults.

One leg standing test [36] is measuring postural control/static balance and the participants were instructed to stand on the optional leg, facing a mark at eye height on the wall three meters away (Figure 1a). The-non-balancing legs heel was to be placed in the knee joint of the supporting leg and the non-balancing legs knee was to be rotated externally. The participants` arms hung alongside their body. One attempt on the optimal leg was carried out, and the total time the participants managed to keep the initial balancing position was recorded in seconds (sec) (minimum 0 sec, maximum 60 sec).

Handgrip strength test [37] was measured by using a hydraulic dynamometer type baseline 90 kilogram (kg) (Chattanooga, Hixon, USA). The dominant hand was to hold the dynamometer, which was used to record the hand grip strength (Figure 1b). The best of three attempts was recorded to the nearest 1 kg.

Static back extension test [59] is measuring endurance capacity of the trunk extensor muscles and the participants were asked to lay face down on a 30 cm tall, 18 cm broad and 135 cm long bench with their iliac crest lined with the bench’s short side, leaving the upper body beyond the bench and their legs fixed on the bench (Figure 1c). The participants were instructed to hold their upper body in a horizontal position for as long as they could and the time (in sec) the participants managed to hold the horizontal position was recorded. One attempt was carried out, and the result was recorded in sec (minimum 0 sec, maximum 240 sec).

Sit and reach test [38] is measuring flexibility of the lower back and hamstring musculature. A standardized box (the length of top of the box was 53.3 cm and the height was 32.5 cm) was placed to a wall and the participants sat on the floor with their knees and upper body straight, and their heels against the box. All the participants completed the test with their shoes on. The participants leant as far as possible along the measuring tape atop of the box, with one hand on top of the other slide along the box and with the back and legs straight (Figure 1d). The furthest the participants managed to stretch their hands along the measuring tape and hold for two sec, was recorded to the nearest half cm. Point zero, the point where the feet met the box was set at 23 cm from the box's edge, and the recorded result was 23 cm plus or minus the distance from point zero, depending on what side of point zero the final reach was recorded. One attempt was carried out, and the result was recorded to the nearest half cm.

Back scratch test [39] is measuring flexibility in the shoulder joint and shoulder arch on the right and on the left side. The participants started the test by standing up right, placing one arm/hand on the lower back, moving it up the spine toward their head. The opposite arm/hand was placed behind their neck, moving it down the spine, aiming to place the long finger of each hand as near each other as possible or to overlap the other hand as much as possible (Figure 1e). The procedure was repeated with opposite arm/hand. The gap between the fingertips of the long finger of both hands was measured to the nearest half cm. The results were recorded to the nearest half cm, as back scratch right arm and left arm over, with positive numbers as long as the fingers overlapped and with negative numbers if the fingers did not meet. One attempt was carried out on each side (right and left arm over), and the result was recorded to the nearest half cm.

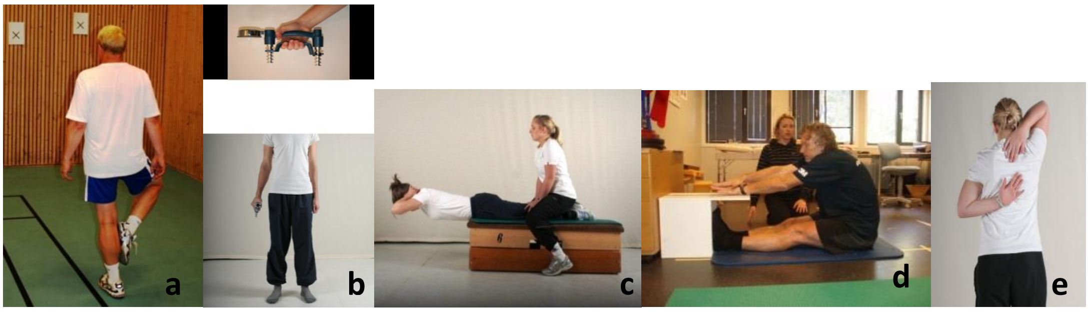

Figure 1a-e. The musculoskeletal fitness- and balance tests used in the present study.

Measurement of physical activity level

We used ActiGraph GT1M accelerometers (ActiGraph, LLC, Pensacola, FL) to assess the participants' physical activity levels [23, 24]. The accelerometer registers vertical acceleration in units called counts, and collects data at a rate of 30 times per second in user-defined sampling intervals (epochs). The number of steps taken per day was registered using the embedded pedometer function [60]. The participants received a pre-programmed accelerometer by mail. They were instructed to wear the accelerometer over the right hip in an elastic band while awake, and to remove the accelerometer when doing water activities. The participants wore the accelerometer for seven consecutive days, and they returned the accelerometer by prepaid express mail after the registration period. We initialized and downloaded the accelerometers using ActiLife software provided by the manufacturer (ActiGraph LLC, Pensacola, FL). Customized SAS based macros (SAS Institute Inc., Cary, NC, USA) were used to reduce the data and derive the number of steps taken per day (spd). Activity files were deemed valid if a participant accumulated at least 10 hours of valid activity recordings per day for at least one day. The protocol for collecting the PA data with the Actigraph is in line with the suggestions by Trost et al. [48]. Wear time was defined by subtracting non-wear time from 18 hours (all data between 00:00 and 06:00 were excluded). Non-wear time was defined as intervals of at least 60 consecutive minutes with zero counts, with allowance for 1 minute with counts greater than zero.

Anthropometric variables

Body height and mass were measured to the nearest 0.1 cm and 0.1 kg, respectively, by the use of stadiometers and body mass monitors (Seca opima, Seca, United Kingdom) whilst wearing light clothing and no shoes. Body mass index (BMI) was computed as body mass (kg) divided by meters squared (m^2).

Other variables

Chronic diseases, medication for high blood pressure and cardiovascular disease, self-reported health (categorized into: “very good”, “good”, “either good or bad”, “poor/very poor”), and education level (categorized into: < high school, high school, university < 4 years, university ≥ 4 years) were conducted through a questionnaire.

Statistical analyses

Based on the Kolmogorov-Smirnov test we considered the data normally distributed. Data are presented as mean and standard deviations (SD), standard errors (SE), or 95% confidence interval (CI) when appropriate.

Student`s t-tests for independent samples were used to assess sex differences in continuous variables (age, height, body mass, BMI), and Pearson`s chi-square analyses were used to assess sex differences in categorical variables (chronic diseases, self-reported health, education level) (Table 1).

Sex and age differences in the test results (one leg standing, handgrip strength, static back extension, sit and reach, back scratch right and left arm over) were examined using univariate analysis of variance (Table 2). When examining differences between age groups (65-69 years, 70-74 years, 75-79 years, and 80-85 years), we adjusted for sex and test center, and when examining differences between sexes in the various tests, we adjusted for age and test center. When presenting total values, we adjusted for sex, age, and test center. When we examined differences in MSF- and balance tests in the different age groups the first step was to test the two-way interaction between sex and age groups, by using general linear model. As no significant interaction was found in neither of the variables the analyses were run for both sexes combined.

Linear regression analyses was used to investigate how physical activity level (expressed as 1,000 steps increments to aid interpretation of the beta coefficients) was associated with the different MSF- and balance tests (Table 3). The MSF- and balance tests were the dependent variables and 1,000 steps increments as the continuous, independent variables. Separate regression models were constructed for each predictor. Crude and adjusted regression coefficients are displayed. Significant interactions between sex*steps and handgrip strength-, sit and reach- and back scratch tests were present. However, running the analyses by sex did not alter any associations in a meaningful way and the analyses are therefore run on the whole sample including age, sex, daily accelerometer wear time and test center as covariates.

All statistical analyses were conducted using IBM SPSS Statistics 19 for Windows (IBM Corporation, Route, Somers, NY, USA). A level of $p \leq 0.05$ was chosen for statistical significance.

Results

Table 1 shows characteristics of the participants. The mean age (SD) was 73.2 (5.4) years for women and 72.3 (4.8) years for men. Men had significantly higher height and body mass compared to women ($p \leq 0.001$). No differences were observed between women and men in chronic diseases (except for osteoporosis: 8% more women reported the disease compared to men, $p=0.04$), self-reported health, and education level.

Table 1. Characteristics of the study sample

Variable	Women	Men	p-value
N	85	76	
[a]Age (yr)	73.2 (5.4)	72.3 (4.8)	0.2
[a]Height (cm)	161.6 (6.0)	175.9 (6.6)	≤0.001
[a]Body mass (kg)	67.0 (10.1)	81.4 (12.2)	≤0.001
[a]BMI (kg/m^2)	25.7 (3.9)	26.4 (3.0)	0.2
Chronic diseases (%)			
CVD[b]	9.8	16.2	0.2
High BP[c]	30.9	25.3	0.4
Poor mental health	5.9	2.6	0.3
Diabetes type II	4.7	6.5	0.6
Osteoporosis	10.6	2.6	0.04
Rheumatism	24.7	15.5	0.2
COPD[d]	2.4	2.6	0.9
Medication[e]	33.8	41.3	0.3
Self-reported health (%)			
Very good	20.0	21.1	
Good	60.0	63.2	
Either good or bad	16.5	14.5	
Poor/very poor	3.5	1.3	
Education level (%)			
<High school	25.3	26	
High school	43.3	35	
University <4 yr	16.9	23.4	
University ≥4 yr	14.5	15.5	

[a] *Data are presented as mean (SD)*

[b] Cardiovascular diseases

[c] Blood preassure

[d] Chronic obstructive pulmonary disease

[e] High BP and CVD

No significant differences were found in self-reported health and education level between women and men

Musculoskeletal fitness and balance by age

Table 2 shows the results from the musculoskeletal fitness- and balance tests, stratified by age and sex. The univariate analysis of variance showed that the participants in the youngest age group had significant better results in one leg standing compared with the participants in the older age groups; 65-69 years compared with 70-74 years: 9.2 sec difference ($p=0.04$), 65-69 years compared with 75-79 years: 17.4 sec difference ($p\leq 0.001$), and 65-69 years compared with 80-85 years: 23.0 sec difference ($p\leq 0.001$). The youngest age group (65-69 years) had also significantly better results in static back extension compared with the participants aged 75-79 years: 27.8 sec difference ($p=0.03$). We found no statistical age differences in the other musculoskeletal fitness test results.

Table 2. Mean (95% CI) musculoskeletal fitness- and balance test results stratified by age and sex

Variable	65-69		70-74		75-79		80-85		All*	
	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men
N	**36**	**36**	**24**	**22**	**15**	**13**	**10**	**5**	**85**	**76**
OLS (sec)	28.2 (22.3-34.2)	26.3 (20.3-32.3)	15.0 (7.8-22.2)	21.3 (13.7-28.9)	9.2 (0.01-18.3)	10.5 (1.0-20.0)	4.9 (-6.3-16.1)	2.0 (-15.8-19.7)	19.2 (15.4-23.0)	19.8 (15.7-23.8)*
All	27.2 (23.1-31.4)^{b}		18.0 (12.8-23.2)^{c}		9.8 (3.2-16.4)^{d}		4.2 (-5.3-13.7)^{e}		19.5 (16.7-22.2)***	
HG (kg)	27.3 (24.6-30.0)	44.3 (41.6-47.1)	24.2 (20.9-27.5)	40.8 (37.4-44.3)	25.5 (21.3-29.7)	42.7 (38.1-47.2)	21.9 (16.7-27.1)	37.1 (29.8-44.4)	25.6 (23.9-27.4)	42.4 (40.5-44.2)*$^{, a}$
All	35.3 (33.4-37.2)		32.0 (29.7-34.4)		33.6 (30.5-36.6)		29.3 (25.1-33.5)		33.5 (32.3-34.8) ***	
SBE (sec)	73.4 (58.1-88.6)	59.2 (44.6-73.9)	66.5 (48.0-85.0)	54.7 (36.2-73.1)	48.4 (25.7-71.0)	28.6 (5.0-52.2)	49.3 (11.4-87.2)	2.1 (-57.8-62.1)	65.6 (55.6-75.7)	49.6 (39.5-59.7)*$^{, a}$
All	66.4 (55.9-76.8)^{f}		60.6 (47.7-73.6)		38.6 (22.4-54.8)^{g}		32.4 (0.4-64.4)		57.7 (50.6-64.8) ***	
SR (cm)	23.5 (20.1-26.9)	14.1 (10.7-17.5)	19.2 (15.1-23.3)	14.2 (9.9-18.5)	17.1 (11.9-22.3)	14.3 (8.9-19.7)	15.9 (9.6-22.3)	4.6 (-5.6-14.7)	20.4 (18.2-22.6)	13.4 (11.1-15.8)*$^{, a}$
All	18.9 (16.5-21.3)		16.8 (13.8-19.8)		15.8 (12.0-19.5)		11.3 (5.9-16.8)		17.1 (15.5-18.7) ***	
BSR (cm)	-5.7 (-9.6--1.7)	-12.9 (-16.8- -8.9)	-8.8 (-13.5--4.0)	-12.9 (-18.0- -7.8)	-7.7 (-13.8- -1.7)	-15.8 (-22.1- -9.6)	-13.0 (-20.4- -5.7)	-15.5 (-27.1- -3.8)	-7.7 (-10.2--5.1)	-13.8 (-16.4- -11.1)*$^{, a}$
All	-9.1 (-11.9--6.4)		-10.7 (-14.2--7.3)		-11.6 (-15.9--7.3)		-14.9 (-21.1--8.6)		-10.5 (-12.4--8.7) ***	
BSL (cm)	-11.2 (-15.2- -7.3)	-19.7 (-23.7- -15.8)	-11.4 (-16.2--6.7)	-17.5 (-22.4- -12.6)	-12.2 (-18.2- -6.2)	-19.3 (-25.5- -13.1)	-18.7 (-26.0- -11.3)	-18.6 (-30.2- -7.0)	-12.3 (-14.8- -9.8)	-19.0 (-21.7- -16.4)*$^{, a}$
All	-15.3 (-18.1--12.6)		-14.3 (-17.7--10.9)		-15.6 (-19.9--11.3)		-20.0 (-26.2--13.8)		-15.5 (-17.3--13.7) ***	

Abbreviations: OLS: one leg standing; HG: handgrip; SBE: static back extension; SR: sit and reach; BSR: back scratch right arm over; BSL: back scratch left arm over
**Adjusted for age and test center*
***Adjusted for sex and test center*
****Adjusted for age, sex, and test center*
[a] *$p<0.05$ between sexes in the different tests*
[b] *65-69 yr compared to 70-74 yr $p = 0.04$, 65-69 yr compared to 75-79 yr $p \leq 0.001$, and 65-69 yr compared to 80-85 yr $p \leq 0.001$*

[c] *70-74 yr compared to 65-69 yr $p = 0.04$*

[d] *75-79 yr compared to 65-69 yr $p \leq 0.001$*

[e] *80-85 yr compared to 65-69 yr $p \leq 0.001$*

[f] *65-69 yr compared to 75-79 yr $p = 0.03$*

[g] *75-79 yr compared to 65-69 yr $p = 0.03$*

Musculoskeletal fitness and balance by sex

The univariate analysis of variance showed that the mean sit and reach results were significantly better in older women (65-85 years) compared with older men (65-85 years) (7.0 cm difference, p≤0.001). Both the mean back scratch right- and left arm over results were also significantly better in women compared with men (6.1 cm difference (p=0.01) and 6.7 cm difference (p≤0.001), respectively). Also, women had significantly better mean static back extension results compared with men (16.0 sec difference, p=0.02). Handgrip strength was significantly better in men compared with women (16.8 kg difference, p≤0.001). We found no significant sex differences in mean one leg standing result.

Physical activity levels, musculoskeletal fitness and balance

Table 3 shows the associations between 1,000 steps increments and the different musculoskeletal fitness- and balance tests. The regression analyses showed that a daily increment of 1,000 steps was associated with significantly better test scores for the one leg standing test and the static back extension test in older adults (65-85 years). For the one leg standing test, an increase of 1,000 steps per day was associated with approximately 2 sec better performance on the test (b=1.88, 95% CI: 0.85 to 2.90, p≤0.001), equivalent to 9.6%. For the static back extension test, an increase of 1,000 steps per day was associated with approximately 5 sec better performance on the test (b=4.63, 95% CI: 1.98 to 7.29, p=0.001), equivalent to 8.9%. For the hand grip test, an increase of 1,000 steps per day was associated with approximately -1.3 kg in performance on the test (b=-1.33, 95% CI: -0.61 to 0.34, p=0.6). For the sit and reach test, an increase of 1,000 steps per day was associated with approximately 0.2 cm in performance on the test (b=0.15, 95% CI: -0.47 to 0.77, p=0.6). For the back scratch test, right and left arm over, an increase in 1,000 steps per day was associated with approximately 0.4 cm (b=0.38, 95% CI: -0.31 to 1.07, p=0.3) and 0.6 cm (b=0.59, 95% CI: -0.10 to 1.29, p=0.09), respectively.

Table 3. Associations between 1,000 steps increments and the different musculoskeletal fitness- and balance variables

Crude		**Adjusted***	
B (SE)	**95% CI**	**B (SE)**	**95% CI**
OLS (sec)			
2.32 (0.48)**	1.36 to 3.28	1.88 (0.52)**	0.85 to 2.90
HG (kg)			
0.22 (0.32)	-0.41 to 0.84	-1.33 (0.24)	-0.61 to 0.34
SBE (sec)			
5.16 (1.21)**	2.77 to 7.55	4.63 (1.34)**	1.98 to 7.29
SR (cm)			
0.44 (0.29)	-0.14 to 1.02	0.15 (0.31)	-0.47 to 0.77
BSR (cm)			
0.68 (0.31)**	0.06 to 1.29	0.38 (0.35)	-0.31 to 1.067
BSL (cm)			
0.76 (0.32)**	0.13 to 1.39	0.59 (0.35)	-0.10 to 1.29

Abbreviations: OLS: one leg standing; HG: handgrip; SBE: static back extension; SR: sit and reach; BSR: back scratch right arm over; BSL: back scratch left arm over

**The adjusted models include age, sex, daily accelerometer wear time, and test center as covariates*
***p<0.05 between 1000 steps increments and test score*

Discussion

The aims of the present study were to; 1) describe musculoskeletal fitness and balance in a random national sample of Norwegian older individuals (65-85 years); 2) examine age- and sex-related differences in musculoskeletal fitness and balance, and 3) to investigate the association between musculoskeletal fitness- and balance with objectively-assessed physical activity levels. The main findings were that the youngest participants (65-69 years) had significantly better static balance and muscular endurance in the trunk extensors compared with the older participants. Also, Norwegian older women (65-85 years) had significantly better upper and lower body flexibility, in addition to better muscular endurance in the trunk extensors compared with older men (65-85 years), whereas the Norwegian older men (65-85 years) had significantly better handgrip strength compared with older women (65-85 years). No sex differences were found in static balance. Further, a daily increment of 1,000 steps was associated with significantly better static balance and muscular endurance in trunk extensors in older individuals (65-85 years).

We found significantly better static balance and muscular endurance in the trunk extensors among the youngest participants (65-69 years) compared with the older participants. Similar results have been found in one other study [12]. This finding might be connected to differences in physical activity level across age groups. We have previously shown a 50% higher activity level among the youngest participants (65-70 years) compared with the oldest participants (80-85 years) [24]. Another possible explanation might be that increasing age leads to a progressive loss of balance [2, 3, 4] and muscular strength and endurance [1], mostly because of degenerative processes in the central and peripheral nervous system [50] and qualitative and quantitative changes in the muscular system [3]. For joint flexibility and handgrip strength we found no significant differences between the youngest and the older age groups, which have been observed in other studies [13, 14, 17, 18]. This discrepancy might be a result of differences in socioeconomic status, cultural differences with respect to retirement age, infrastructure and degree of environmental security among the populations studied.

We found significantly better joint flexibility in older women (65-85 years) than in older men (65-85 years) which is in accordance with the findings from previous studies [17, 18, 34, 39, 41]. A possible explanation for these sex-related differences in joint flexibility might be related to differences in physical activity patterns among older men and women. We have previously shown that Norwegian older women spent more time (minutes) on low-intensity physical activity than did their male counterparts [24]. This observation was confirmed in the present study because we found that women spent significantly more time each day performing low-intensity physical activity compared with the men (216 versus 190 minutes (p=0.001), respectively) (data not shown). We could therefore speculate whether daily low-intensity activities such as washing dishes, hanging washing, ironing and cooking might affect joint flexibility in older women by limiting the age- and activity-related deterioration. Other factors that might play a role regarding sex-related differences in joint flexibility are; anatomical and physiological differences, smaller muscle mass and different joint geometry and collagenous muscle structure [51]. Older Norwegian older men and women also seemed to have somewhat better mean flexibility in lower back and hamstring musculature than what has been reported among elderly in the USA [39] and among elderly in Spain [17]. This discrepancy might be explained by different test procedures as the two latter studies used chair sit and reach test, in addition to including a broader age range (60-85+). Shoulder joint- and arch flexibility also seemed to be somewhat better among Older Norwegian men and women compared with older men and women in Spain [17]. The exact same test procedure was used in the two studies. Therefore, the discrepancy might be related to differences in sample sizes and age ranges as Gusi et al. [17] included 6.449 participants aged 60-94 years old. Furthermore, we also found significantly better muscular endurance in the trunk extensors in women than in men. This sex-related difference might be related to mechanical principles during the static back extension testing, meaning that women`s shorter and lighter upper body compared with the longer and heavier upper body of men creates a shorter lever arm resulting in a smaller torque in women than in men. This may make it easier for women to maintain the correct position for a longer period. In addition, women might be performing more domestic activities on a daily basis than men which require them to stand in an upright position (e.g. when washing dishes, hanging washing, ironing, and cooking). This might affect the muscular endurance capacity in the trunk extensors by limiting age- and activity-related deterioration [40].

Men had significantly better handgrip strength than women, which is in accordance with other cross-sectional studies where dynamometers were used [13, 14, 15, 16, 17]. Our population appeared to have somewhat better handgrip strength than what has been reported in studies from Brazil and Australia [15, 16]. This discrepancy might be related to different selection of participants, cultural differences with respect to sex equality across countries (e.g. distribution of work regarding household and gardening), in addition to differences in test procedure, like measuring grip strength seated [16] instead of standing in an up-right position which was done in the present study. It has to be mentioned though, that this comparison is based on a difference in age range (65-85 years versus ≥70 years), which also has to be taken into consideration when comparing our findings with the referred studies above.

We found no sex differences in static balance which is in contrast to one other study, showing significantly better static balance in older men than in older women [41]. A possible explanation for not finding any sex-related difference in the static balance among older Norwegian adults might be related to their physical activity level. We have previously reported no sex-related differences in overall physical activity level within the different age groups among older Norwegian adults [24]. This observation was confirmed in the present study, as we found no sex-related differences in the number of steps taken per day (7,551 for women versus 7,356 for men, p=0.7) (data not shown). Norwegian older men and women seemed to have better static balance compared with 60-80 year old Iranian men (n=36) and women (n=40) [41]. Older Norwegian women appeared to have somewhat lower static balance results compared with what has been reported among 60-86 year old American women (n=71) [12]. This variation in measured values for one leg standing time might be related to differences in the populations examined (e.g. sample size, high versus low functioning elderly) as well as procedural differences (e.g. shoes on, barefooted, dominant-, non-dominant leg, eyes open, eyes closed), which might affect the results. [42].

We found that a daily increment of 1,000 steps was associated with significantly better static balance and muscular endurance in the trunk extensors in older Norwegian individuals. This knowledge may be of importance towards developing and initiating future preventive health strategies aiming at older adults, Attention should be given to balance and muscular endurance, as both components seem to have relevance to overcome activities of daily living [8, 40]. A recently published study by de Melo et al. [31] reported that agility/balance was significantly associated with pedometer-assessed steps taken per day when comparing older Canadian adults categorized as “high walkers” (mean steps for 3 days: ≥6,500) with “low walkers” (mean steps for 3 days: <3,000) (n=60, mean age 76.9 years). However, body sway/static balance was unrelated to accelerometer-defined measurement, expressed as daily step counts, in older Japanese men (n=94) and women (n=76), aged 65-84 years [30]. In addition, hand grip strength was also unrelated to daily step counts in this elderly Japanese cohort, which is in line with our results. Furthermore, we found no association between a daily increase of 1,000 steps and upper- and lower joint flexibility. In contrast, de Melo et al. [31] reported significantly better lower body flexibility in “high walkers” than in “low walkers”. To our knowledge, no prior work has examined the associations between muscular endurance in the trunk extensors and physical activity among older adults, which makes our results rather novel. However, there are existing studies [45, 52, 53] looking at the association between muscular endurance in the trunk extensors, physical activity and health related factors. These studies are all aiming at younger age groups, in addition to use of subjectively-assessed physical activity level through a questionnaire, which makes a comparison rather inappropriate.

One of the major strength of this study is the use of standardized musculoskeletal fitness and balance tests, with high validity, reliability, safety and feasibility. Furthermore, we used an objective assessment of physical activity, and the participants showed good compliance with the protocol and few data were lost because of insufficient wearing time or defect monitors. The participants achieved a mean of 6.6 days (SD 1.4) with valid activity recordings, and the mean wear time was 14.0 hours per day (SD 1.2) [24].

We acknowledge some limitations to our study. The relatively low participation rate might question the representativeness of the data. A drop-out analysis performed via registry linkage showed that the responses varied according to socio-demographic variables [23]. Several test centers and test leaders were involved in the data collection and this might have influenced the reliability of the data. To minimize this limitation a test protocol together with illustrating test procedure posters were developed, followed by a pilot study where all the tests were accomplished prior to the main study. Also, the test leaders were trained in the test protocol and test procedures. Furthermore, there are limitations worth noting when interpreting accelerometry data [43]. Walking technique must be taken into consideration because it can affect the validity of accelerometer step counts, especially in older individuals [43]. It appears that some accelerometers can undercount activity in individuals with a nonstandard gait (e.g. upper body angled forward and knees bent during walking), thereby underestimating the activity level in these individuals [44]. Another limitation is that only one test of static balance was included and that muscular strength was only examined via handgrip dynamometer. Also, as in any observational study, we have to be cautious in inferring causality based on our findings.

Conclusion

The youngest participants (65-69 years) among older Norwegians had significantly better static balance and muscular endurance in trunk extensors compared with the older participants. Older Norwegian women (65-85 years) had significantly better upper and lower body flexibility, in addition to significantly better muscular endurance in the trunk extensors compared with older men (65-85 years), whereas older Norwegian men (65-85 years) had significantly better hand grip strength compared with older women (65-85 years). No sex differences were found in static balance. A higher physical activity level, expressed as daily increments of 1,000 steps, was associated with significantly better static balance and muscular endurance in the trunk extensors in older Norwegians (65-85 years). Our results may be of importance towards establishing future preventive health strategies aimed at community-dwelling older men and women, and a focus should be given to balance, joint flexibility and muscular strength and endurance.

List of abbreviations

BSL: back scratch left arm over; BSR: back scratch right arm over; CI: confidence interval; HG: hand grip; MSF: musculoskeletal fitness; OLS: one leg standing; PA: physical activity; SD: standard deviation; SR: sit and reach.

Competing interests

The authors declare that they have no competing interests. The results of the present study do not constitute endorsement by the BMC Geriatrics.

Authors` contributions

SAA contributed to the conception and design of the study. BHH was responsible for the collection of the KAN data in corporations with colleagues at nine other test centers throughout Norway. HLS undertook the data analysis and drafted the manuscript. All authors provided critical insight, and revisions to the manuscript. All authors read and approved the final version of the manuscript submitted for publication.

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PAPER III

Reliability and validity of chair-stand and box-lift tests in elderly individuals.

H. Lohne-Seiler[1,2], S.A. Anderssen[2] , A. Blazevich[3], M.K. Torstveit[1]

[1]University of Agder, Kristiansand, Norway, [2]Norwegian School of Sport Sciences, Oslo, Norway, [3]Edith Cowan University, Perth, Australia

Corresponding author:

Hilde Lohne-Seiler. University of Agder, Faculty of Health and Sport Sciences,
Service Box 422, N-4604 Kristiansand, Norway.
Phone: + Int 47 38 14 12 89
E-mail: hilde.l.seiler@uia.no

Co-authors:

Sigmund Alfred Anderssen. Norwegian School of Sport Sciences, Department of Sport Medicine, P.B. 4014 Ullevaal Stadion, 0806 Oslo, Norway. E-mail: s.a.anderssen@nih.no

Anthony Blazevich. Edith Cowan University, School of Exercise and Health Sciences, 270 Joondalup Drive Joondalup WA 6027, Perth, Australia. E-mail: a.blazevich@ecu.edu.au.

Monica Klungland Torstveit. University of Agder, Faculty of Health and Sport Sciences, Service Box 422, N-4604 Kristiansand, Norway. E-mail: monica.k.torstveit@uia.no.

Abstract

Background: Tests evaluating function in the elderly should be designed for assessing relationships between muscle strength and power. The focus of this study was therefore to determine whether the 30-s chair-stand test (CS_{field}) and a modified version of the progressive isoinertial lifting evaluation test ($PILE_{field}$) were valid tests for assessing relationships between: 1) lower extremity strength and power, and 2) total lifting strength and power, in elderly. Also, reliability across trials and days was investigated. **Method:** Nineteen participants (72.4±5.0 years) attended. Testing was completed three days apart to quantify test-retest reliability. Validity was determined by comparing performances in the two field-based tests with laboratory-based versions (CS_{lab}, $PILE_{lab}$), using a force platform and linear encoder. All tests were performed “as fast as possible”. Intra-class correlations (one way random effects model) were used to calculate intra- and inter-day reliability. Intra-class correlations (two-way mixed model) were used to determine the validity between the two test performances; field- and laboratory based tests. **Results:** The intra-day reliability of CS_{lab} and $PILE_{lab}$ were high (ICCs = 0.81-0.99, $p<0.01$). The inter-day reliability of both field- and laboratory versions were acceptable (ICCs = 0.71-0.95, $p<0.01$). However, ICCs computed between performances in the field- and laboratory versions of CS and PILE were lower (ICCs = 0.36, $p=0.49$ and = 0.72, $p=0.48$, respectively). **Conclusions:** These findings indicate a relatively high intra- and inter-day reliability of the field-based chair-stand and box-lift tests but they may not be valid for assessing relationships between muscle strength and power in elderly individuals. Further investigation should utilize tests specially designed for use in elderly populations in order to assess relationships between muscle strength and power in a functionally relevant way.

Key words: Functional strength tests, quantify, muscular power, seniors.

Background

Muscle strength and power are important determinants of independent mobility [1]. In aging, muscle power seems to decline earlier [2] and faster [3] than muscle strength and muscle power has been shown to be positively associated with the ability to perform activities of daily living. It may also be a stronger predictor of functional dependence than muscle strength with increasing age [4, 5].

A significant correlation exists between leg extensor power and performance measures such as chair rise, stair climb, and fast walking ability [5, 6] and muscle power is also related to dynamic balance [7] and postural sway [8] and may be a stronger predictor of fall risk than muscle strength [9]. Furthermore, increases in muscle power may lead to improvements in functional capacity, and thus prevent falls, dependency and disability later in life [10]. Therefore, the measurement of muscle power, in addition to measures of muscle strength, should be a focus of clinicians and researchers working with elderly and/or clinical populations.

Field-based, rather than laboratory-based tests are the most commonly used to measure function in elderly populations, with the purpose of measuring muscle strength rather than muscle power. Field-based tests evaluating lower and upper body strength often include assessing the number of chair rise repetitions performed within a specified period of time (e.g. 30-s chair-stand test: Jones, Rikli, & Beam [11]) or determining the total number of consecutive repetitions an individual is able to perform (e.g. arm curl test in the Senior Fitness Test battery: Rikli & Jones [12]). However, it may be speculated that these field-based tests are less valid for the measurement of muscle strength than muscle fatigue resistance, although Jones et al. [11] showed a moderately high correlation (r = 0.78 for men and r = 0.71 for women) between chair-stand performance and maximum leg-press strength in the elderly. Furthermore, Rikli and Jones [12] found a moderate correlation (r = 0.62 for men and r = 0.68 for women) between the 30-s arm-curl test performance and maximum biceps strength in the elderly. Thus, more research is required to determine the validity of higher-volume repetitive tests for the assessment of muscle strength and, in particular, muscle power.

Another consideration is that, if the intention is to evaluate functional capacity (i.e. person`s ability to perform a work-related series of tasks) among elderly individuals, a greater focus is needed on testing integrated movements involving several muscle groups rather than using simple tasks measuring isolated muscle groups. Test performances could then be considered more similar to the physical challenges that are required in activities of daily living, e.g. lifting an object or rising from a chair. The progressive isoinertial lifting evaluation (PILE) test by Mayer et al. [13] requires total body lifting capacity and consists of two parts, one lift from floor to hip height (lumbar test) and one lift from hip height to above shoulder height (cervical test). The PILE test is therefore considered a useful, multi-joint functional test. However, two-part lifting tests like the original PILE test [13] could be considered less functional when compared with a lifting test performed in one continuous movement. When objects are lifted from the ground to a high level in a single movement, there is a requirement for a higher degree of integrated muscle recruitment, and these muscle recruitment strategies are more similar to many activities of daily living. Based on this, a single continuous lifting test could be considered as a more valid and functionally relevant when compared with a two-part lifting test.

A final consideration is that field-based tests evaluating function in the elderly should be designed for assessing relationships between muscle strength and power. Based on this, the validity of the 30-s chair-stand [11] and PILE [13] tests could be questioned for the purpose of assessing relationships between muscle strength and power among elderly people because their high-volume lifting requirement is more targeted towards muscle fatigue assessment. However, no data are currently available to test this hypothesis. Given these considerations, the aim of the present study was to test the hypothesis that the field-based 30-s chair-stand test (CS_{field}: number of chair stand repetitions completed in 30 s) and a modified field-based version of the progressive isoinertial lifting evaluation test ($PILE_{field}$: loaded box lifted from floor to chin) were valid tests for assessing relationships between: 1) lower extremity strength (measured as multi-joint repetitive chair-stand performance) and muscle power, and 2) total lifting strength (measured as multi-joint repetitive box-lifting performance) and muscle power, in elderly individuals. Validity was determined by comparing performances in the two field-based tests (CS_{field} and $PILE_{field}$) with laboratory-based versions of the tests (CS_{lab} and $PILE_{lab}$). In addition, reliability across trials (intra-day reliability) for the laboratory-based tests and reliability across days (inter-day reliability) for the field- and laboratory-based tests were also investigated.

Methods

Participants and study design

Nineteen elderly individuals (14 men and 5 women) volunteered for the study after ensuring an advertisement in the local newspaper. Prior to participation, all the elderly reported their health history, perceived health status (i.e. very good, good, bad or poor/very poor health) and physical activity level through a questionnaire and received a medical clearance from their medical doctor/physician, either in a written or verbal form. A comprehensive questionnaire asking for details regarding the persons` level of physical activity was used, including activities of daily living and common exercise modes, from which information pertaining physical activity level being more or less than 30 min per day at moderate intensity (or high-intensity equivalent) was taken. Inclusion criteria were: 65 years and older and physically active less than 30 min per day at a moderate intensity. Exclusion criteria were: physically active more than 30 min per day at a moderate intensity [14], participating in specific strength training, involved in other studies interfering with the present study, cognitive impairment, acute or terminal illness, or severe cardiovascular-, respiratory-, musculoskeletal-, or neurological diseases disturbing voluntary movement. The inclusion and exclusion criteria were chosen to make sure that the participants were relatively physically inactive and homogenous regarding their health status and physical activity levels.

The participants completed a 15-min warm-up before testing, which included fast walking and active arm movements, as well as 3-5 min of upper and lower extremity muscle stretching. The warm-up routine was performed to ensure they were physically prepared for the strength testing and to decrease injury risk. Testing was completed on two occasions, 3-4 days apart and at the same time of the day to quantify test-retest reliability across days (inter-day reliability). A comparison was made between the field-based tests (CS_{field}, $PILE_{field}$) and the laboratory-based tests (CS_{lab}, $PILE_{lab}$) to determine test validity. The same test procedures were followed at day one and day two.

To assure that all participants were familiar with the different test procedures and the correct technique, they completed 2-3 full familiarization sessions in the weeks prior to the testing, which also formed part of the final pilot testing phase. The participants also performed several practice repetitions before the testing started. Prior to these test attempts, an instructor demonstrated the test procedures and techniques to show how the tests should be conducted. The participants also received direct visual feedback during the testing by performing the tests in front of a mirror. The study was approved by the Regional Ethics Committee for Medical Research and the Norwegian Data Inspectorate. All the participants provided informed consent prior to the study.

Measures

The procedures for the laboratory-based tests (CS_{lab}, $PILE_{lab}$), were established based on a pilot study. In order to measure power, the MuscleLab software system 4010 / 4020e [15] was used, which is a portable system for evaluation of movement performance and is considered a reliable device for measuring average power [16]. To minimize muscle fatigue in the working muscle groups, the tests were carried out in the following order; 1RM isometric dead lift test, $PILE_{field}$, CS_{field}, $PILE_{lab}$ and CS_{lab} tests.

CS_{field} test. The CS_{field} test was used to measure the ability to accomplish repetitive chair-stand rapidly (lower extremity strength). The participants started the test sitting on a chair (height 46.0 cm, depth 44.5 cm), with the arms across the chest, their back touching with the chair's backrest, the feet shoulder-width apart and the knees flexed to 90^o. They were asked to stand up to a straight position and re-sit as many times as possible in 30 s, without pushing off with their arms. The participants were encouraged to work "as fast as possible" during the chair standing. The number of repetitions completed in 30 s was taken as a measure of performance.

CS_{lab} test. The CS_{lab} test was used to measure lower extremity power and was performed on a force platform (Figure 1a) connected to the integrated software system. The participants started the test sitting on the same chair that was used for the CS_{field} test, and the arms, back and feet in the same position as described above. When signaled the participants were asked to stand up to a straight position as fast as possible, without pushing off with their arms, and then slowly sit back on the chair seat. Power output was measured as vertical force times distance divided by time. The average of the two best trials of five (approximately 2 s between each trial) was recorded as the result.

PILE$_{field}$ test. The PILE$_{field}$ test was used to measure the ability to lift loads rapidly (total lifting strength), and consisted of repeated lifts of a progressively heavier box from floor to chin height in one continuous movement. To make sure the participants performed the PILE$_{field}$ test using the correct technique they were asked to start the lift with bent knees and elbows, the box close to their body and a straight back. Whilst extending the knees and elbows, the box went up to chin height in one continuous movement. In addition, to better control for a straight vertical movement of the box, the participants were asked to look straight ahead. During the lifts, the movement techniques were observed by an instructor at all times, in order to ensure the correct techniques were used. The participants lifted a light (1 kg) box in which sand-filled containers weighing 2.25 kg each were placed in order to increase the load incrementally during the test. The women started the test lifting the box filled with one container (2.25 kg) and the men started by lifting the box with two containers (4.5 kg). The participants were encouraged to work as fast as possible and exert maximal power (a combination of fast speed and explosive work) during the box lifting. The load was increased every 20 s by 2.25 and 4.5 kg for the women and men, respectively, until a maximum lifted load was achieved (when the participants could no longer lift the box using the correct technique). The total load lifted in the final repetition was taken as the participant’s final result.

PILE$_{lab}$ test. The PILE$_{lab}$ test was used to measure lifting power capacity, and was performed using linear encoder and load cell (Figure 1b) connected to the integrated software system. To make sure the participants performed the PILE$_{lab}$ test using the correct technique they were asked to use the same procedures as described in the PILE$_{field}$ test. The participants were encouraged to work "as fast as possible" during the box lifting. Power output was measured as vertical force times distance divided by time. The average of the two best trials out of five (approximately 2 s between each trial) was recorded as the result. During the PILE$_{lab}$ test, the women lifted 10% and the men 15% of the maximum achieved during a maximal isometric dead lift test performed 45-60 min prior to the PILE$_{lab}$ test. For the 1-RM deadlift test, peak isometric force was measured using a tension load cell connected to the integrated software system. The participants were encouraged to exert maximal force during the test. The best, of two attempts were recorded. A total of 10% (women) and 15% (men) of the "average" maximum loads (kg) were calculated and then used during the PILE$_{lab}$ test. The working intensity (10 and 15% of 1RM isometric dead lift test for women and men respectively) in the PILE$_{lab}$ test was established in the pilot study in order to make sure that the participants worked using correct ergonomic principles (box close to body, bended knees and straight back) and this way avoid injuries during the lifts.

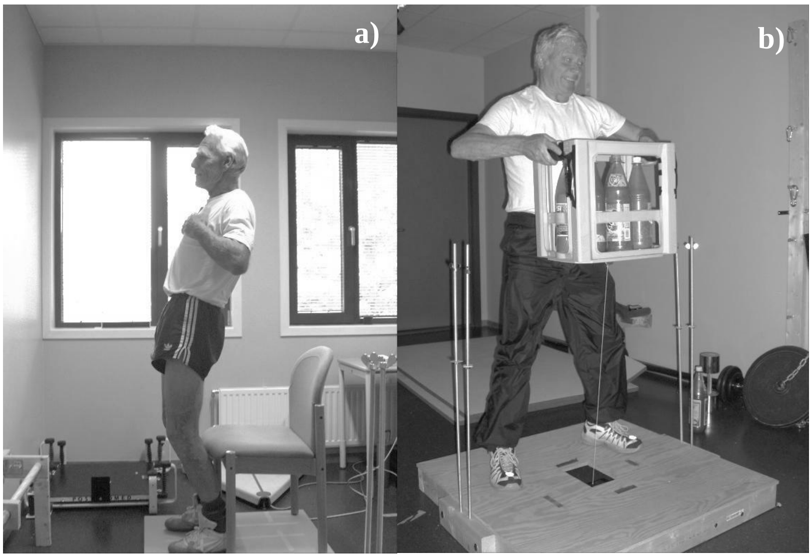

Figure 1. The laboratory based tests; a) chair-stand power test (CS$_{lab}$) and b) PILE power test (PILE$_{lab}$).

Anthropometric data. Body height and mass were measured using measuring tape and body mass monitor (Seca opima, Seca, United Kingdom) twice per participant whilst wearing a T-shirt, shorts and no shoes, prior to the first test day. The results are given as a mean of two measurements.

Data analysis

All analyses were conducted using Microsoft Excel and PASW Statistics (v 18).

To determine whether five repeated measurements on the same day were similar (intra-day reliability): Intra-class correlations (ICCs, one-way random effects model) with 95% confidence interval (CI) were computed to calculate the correlations across trials for CS$_{lab}$ and PILE$_{lab}$ tests, repeated measures ANOVAs with pairwise comparisons were used to analyze the mean differences across trials (mean ± SD). Day one was used for the five repeated trials analysis.

To determine test-retest reliability from day one to day two (inter-day reliability): ICCs (one-way random effects model) with a 95% CI were calculated to determine reliability across days for CS_{field}, CS_{lab}, $PILE_{field}$ and $PILE_{lab}$ tests, and a paired-samples t-test was used to examine the mean differences from days one to two. Descriptive statistics for the field- and laboratory-based tests at day one and day two were also computed.

To determine the validity between the two test performances (field- and laboratory-based tests): ICCs (two-way mixed model) with 95% CI were computed. The number of unsupported chair stand repetitions in the CS_{field} test was compared with the calculated average power during single “as fast as possible” sit to stand movements performed on a force platform (CS_{lab} test). The maximum load lifted in the modified version of the $PILE_{field}$ test was compared with the calculated average power directly measured with the linear encoder attached to the box during single “as fast as possible” box lifting trials ($PILE_{lab}$ test). Data obtained on test day one were used for the validation analysis.

For the present study, correlations of 0.0-0.2 were interpreted as very weak, 0.2-0.4 as weak, 0.4-0.7 as moderate, 0.7-0.9 as high and 0.9-1.0 as very high [17], and with a 95% CI in an acceptable range of 0.8-1.0. ICC analyses are considered sensitive to systematic error [18], and were therefore most appropriate for use in the present study. The level of significance was set at an alpha level of 0.05.

Results

The mean age of the total sample (n=19) was 72.4±5.0 y (range 67-90 y), average height, mass, and body mass index (BMI) were 1.75±0.86 m, 71.4±9.1 kg and 23.1±2.1 kg/m^2, respectively. The participants in this study lived at home with no assistance and no use of walking aids. Through the questionnaire, all participants reported a physical activity level less than 30 min per day at moderate intensity. Common activities among the participants were walking/strolling, swimming, gardening, and household activities. In addition they perceived their health as very good or good, and did not report any severe diseases or use of daily analgesics. One participant was excluded from the study for medical reasons.

Intra-day reliability of laboratory-based tests

Mean values (±SD) for the five repeated trials performed at day one for the laboratory-based test are reported in Table 1. The ICCs computed across five repeated trials for CS_{lab} and $PILE_{lab}$ tests performed at day one were high to very high, ranging 0.81-0.99 ($p<0.01$) and 0.92-0.98 ($p<0.01$), respectively. The 95% CIs were in an acceptable range for $PILE_{lab}$ and for CS_{lab} (0.90-0.98 and 0.67-0.87, respectively). ICCs for both CS_{lab} and $PILE_{lab}$ were least (0.81, $p<0.01$ and 0.92, $p<0.01$, respectively) between the first and the fourth trials and greatest (0.98, $p<0.01$ and 0.98, $p<0.01$) between the second and third trials. No significant mean differences across trials were revealed ($p>0.05$).

Table 1. Mean values and standard deviation (SD) for five repeated trials performed at day one for CS_{lab} and $PILE_{lab}$ tests.

CS_{lab} (W) (trial 1-5)	**Mean (+SD)**	**$PILE_{lab}$ (W)** (trial 1-5)	**Mean (+SD)**
$CS_{lab}1$	840.0(246.9)	$PILE_{lab}1$	1355.3(417.6)
$CS_{lab}2$	841.9(260.7)	$PILE_{lab}2$	1361.4(377.0)
$CS_{lab}3$	821.9(252.2)	$PILE_{lab}3$	1312.1(388.5)
$CS_{lab}4$	817.7(273.8)	$PILE_{lab}4$	1340.1(418.2)
$CS_{lab}5$	813.2(266.0)	$PILE_{lab}5$	1362.4(457.3)

Inter-day reliability of field- and laboratory-based tests

The inter-day-reliabilities (ICCs) of the field- and laboratory-based tests are reported in Table 2. Test-retest correlations across days for CS_{field}, CS_{lab}, modified $PILE_{field}$ and $PILE_{lab}$ tests were respectively moderate, very high, very high and high, with ICCs ranging 0.71-0.95 ($p<0.01$). The 95% CIs were in an acceptable range for CS_{lab} and $PILE_{field}$ (0.86-0.98 and 0.84-0.91, respectively) but in an unacceptable range for CS_{field} and $PILE_{lab}$ (0.38-0.89 and 0.52-0.93, respectively). No significant ($p>0.05$) mean differences from day one to day two were revealed for these tests.

Table 2. Inter-day reliability of field- and laboratory-based tests.

	ICC	**Mean (± SD)**		**P-value**
		(Range)		
	[95% CI]	Day 1	Day 2	(ΔDay 1 - Day 2)
CS$_{field}$ (no. reps)	0.71 [0.38-0.89](p<0.01)	17.2 ± 2.6 (14.0 - 22.0)	17.1 ± 2.2 (12.0 - 21.0)	0.70
CS$_{lab}$ (W)	0.95 [0.86-0.98] (p<0.01)	826.2 ± 242.2 (402.0 - 1395)	844.6 ± 265.5 (388.4 - 1248)	0.41
PILE$_{field}$ (no. bottles)	0.94 [0.84-0.91] (p<0.01)	6.8 ± 3.1 (2.0 - 12.0)	6.8 ± 2.7 (2.0 - 12.0)	1.00
PILE$_{lab}$ (W)	0.81 [0.52-0.93] (p<0.01)	1406 ± 433.4 (706.2 - 2164)	1447 ± 359.3 (643.9 - 1958)	0.54

ICC = intra-class correlation, 95% CI = 95% confidence interval, Range = the least and the greatest scores obtained by any participant for each test on day one and two

Relationships between field- and laboratory-based test performances

ICCs between the field and laboratory versions of CS and PILE tests performed on day one were weak (0.36, p=0.49) and strong (0.72, p=0.48), respectively, with the 95% CIs in an unacceptable range (-0.44-0.45 and -0.47-0.49, respectively). Thus, the validity of the field-based chair-stand and box-lift tests was deemed to be poor when compared to the laboratory-based test because insignificant relationships and unacceptable CIs were found in both test comparisons.

Discussion

This present results reveal a poor validity (low ICCs with unacceptable CIs) of the field-based versions of the chair-stand and box-lift tests, however, the intra-day reliability of CS_{lab} and $PILE_{lab}$ were high and the inter-day reliability of both the field- and laboratory versions of CS and PILE tests were also generally high. Thus, the field-based tests might be useful to examine functional performance in elderly populations, but cannot be considered as surrogates for the laboratory-based tests, and therefore also cannot be considered valid tests for assessing relationships between strength and power.

Several previous studies [11, 19, 20] have found good relationships between chair-stand performance and a laboratory-based measure using a non-functional 1RM leg press test, which has the purpose of measuring maximum muscle strength. Nonetheless, the leg press exercise is dissimilar in its movement pattern to most activities of daily living, so the functional value of the leg press test could not be clearly ascertained. One published study [21] used a force platform to measure power output during the 30-s chair rise test in 14 older adults. They reported a significant correlation between the average power output during the chair rises and predicted power developed through equations based on body mass and the number of chair rises performed during the first 20 s of the 30-s trial. These results indicate that lower body muscle power in older adults might be accurately evaluated using data from the initial 20 s of a simple 30-s CS test. Although there were similarities in the testing tool (e.g. the use of a force platform) in our study compared with the study by Smith et al. [21], differences in the testing procedures could explain the strong correlation detected by Smith et al. [21]. No studies were found that specifically examined the validity of the PILE test. However, a number of studies have used the test or compared PILE results with other measures (see review by Innes [22]). We believe that the use of a force platform to measure power output during chair rises, and a linear encoder and load cell to measure lifting power capacity for validation purposes have functional value in the assessment of elderly individuals and should therefore be investigated further. It is also necessary to emphasize that there may be some methodological issues concerning how validity was determined by comparing performances in the two field-based tests (the number of unsupported chair stand repetitions and the maximum load lifted in the box-lift test, respectively) with calculated average power in the laboratory-based versions (CS_{lab}, $PILE_{lab}$), using a force platform and linear encoder. However, we found the methods to be appropriate after which the purpose of the study, which was to assess relationships between muscle strength and power in functional tests designed for elderly individuals.

The lack of significant correlations between the field- and the laboratory versions of the CS and PILE tests in the present study indicate that the field-based versions are not valid for assessing relationships between muscle strength and power among elderly individuals, even though the test procedures in both versions were performed “as fast as possible” with integrated movements involving several muscle groups and a strict routine to control for the correct lifting strategy. The fact that the participants were quite homogenous (i.e. physical activity level and health status) should be considered, because a small spread of data will reduce the magnitude of correlations. Since performances were compared within individuals, we do not believe the participants` physical- and functional levels explain the low validity in this study. The uneven distribution of women compared to men might be considered to have influenced these results and could probably make the generalization rather difficult, however ICCs analysis, split by sex, revealed the similar picture in the validity of test performances.

The intra-day reliability of the two laboratory-based tests (CS_{lab} and $PILE_{lab}$) was considered as relatively high based on the ICCs, the lack of significant performance differences between trials and the 95% CIs being in an acceptable range. These results support the indication of high test-retest reproducibility across trials and could probably be explained by the strict and standardized test protocol used in the present study. However, the intra-day reliability of the field-based tests should have been considered to be evaluated in this study, given that most researchers [11, 13, 20, 23, 24] have investigated the test-retest reproducibility across days (see below) rather than across trials. More research is therefore needed for the purpose of looking at test-retest reproducibility across trials of the-field based tests used in the present study.

The inter-day reliability of the two field-based tests (CS_{field} and $PILE_{field}$) was considered relatively high based on the ICCs (see Table 2) and the lack of significant performance differences between days one and two. The range of scores on test days one and two was also similar for both field-based tests, supporting the finding of high test-retest reproducibility. Despite this, the 95% CIs were unacceptably wide for CS_{field}, which may be related to the sample size and a slight variability in the individuals` reliability. Similar results have previously been reported by Jones et al. [11], who showed a non-significant change in scores from day one to day two (2-5 day interval), indicating that the field-based test had good reliability across days. Other studies have also concluded that the 30-s chair-stand test has good test-retest reliability across days in older adults [20, 23, 24]. Our $\text{PILE}_{\text{field}}$ inter-day reliability result was consistent with those of Mayer et al. [13], who found adequate test-retest reliability for the two-part lumbar- and cervical version of the test. A similar result in the one-part (cervical only) lift was also found in the study by Horneij, Holmström, Hemborg, Isberg, & Ekdal [25]. As described in the Method section, we used one continuous lifting procedure in the PILE test, which is different to the original two-part lifting PILE test (a cervical and lumbar lift) used by others [13, 25]. Therefore a comparison of the reliability is rather difficult. To our knowledge no previous studies have examined test-retest reliability of the PILE test using one continuous lift.

The inter-day reliability of the two laboratory-based tests (CS_{lab} and PILE_{lab}) was also considered relatively high based on the ICCs (see Table 2) and the lack of significant performance differences between days one and two. The range of scores on test days one and two was quite similar for both laboratory-based tests, supporting the finding of high test-retest reproducibility. Despite this, the 95% CIs were unacceptably wide for PILE_{lab}, which may be related to the sample size and a slight variability in the individuals` reliability.

Based on these results, the relatively high inter-day reliability of both the field- and the laboratory-based tests shown in our study indicates that the CS_{field}, the CS_{lab}, the $\text{PILE}_{\text{field}}$ and the PILE_{lab} tests have a high reproducibility, which may be of great importance for the future application of these tests.

The 1RM isometric dead lift test was used to establish the working load in the PILE$_{lab}$ test, which means that a static (isometric) test was used to decide the load in a dynamic (isotonic) test. We used the static maximum test for safety reasons (easy to control for correct ergonomic principles) and because it utilized the same working position as the dynamic test, which would likely resulted in similar muscle recruitment.

Given the importance of muscle power, compared to muscle strength, as a predictor of functional independence with increasing age [4, 5, 9] tests are required that can assess relationships between strength and power performance in elderly populations. Unfortunately, the present results indicate that field-based versions of the chair stand and the modified box lift (one continuous lift) tests do not measure the same properties as the laboratory-based tests; i.e. their validity was poor. Thus, these tests do not seem to assess relationships between strength and power performance, and are most likely rather measures of muscle fatigue resistance. More research is therefore necessary to develop functional tests that assess relationships between muscle strength and power. On the other hand, the relatively high intra- and inter-day reliability shown in our study indicates that both the field- and the laboratory-based tests have a high reproducibility which may be of great importance for researchers, geriatricians and other health professionals. In addition, the tests used to measure lifting capacity and the ability to rise from a chair, which are fundamental abilities for autonomy of the elderly, are highly portable and are cost-effective and simple methods, making them easy to implement in various testing environments.

Conclusion

The results in the present study indicate a relatively high intra- and inter-day reliability of the field-based chair-stand and box-lift tests but they may not be valid for assessing relationships between muscle strength and power in elderly individuals. Our findings are therefore of importance in future development of reliable field- and laboratory-based test procedures when measuring the ability to rise from a chair and lifting capacity in elderly people. Future studies should utilize tests specially designed for use in elderly populations in order to assess relationships between muscle strength and power in a functionally relevant way.

Abbreviations

CS_{field}: field-based version of the chair-stand test, $PILE_{field}$: field-based version of the box-lift test, CS_{lab}: laboratory-based version of the chair-stand test, $PILE_{lab}$: laboratory-based version of the box-lift test, BMI: body mass index, ICCs: intra-class correlations, CI: confidence interval, SD: standard deviation.

Competing interest

The authors declare that they have no competing interests. The results of the present study do not constitute endorsement by the BMC Medical Research Methodology.

Authors' contributions

HLS contributed to the conception and design of the study, was responsible for the collection of the data, provided the data for analysis, and drafted the manuscript. All authors provided critical insight, and revisions to the manuscript. All authors read and approved the final version of the manuscript submitted for publication.

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PAPER IV

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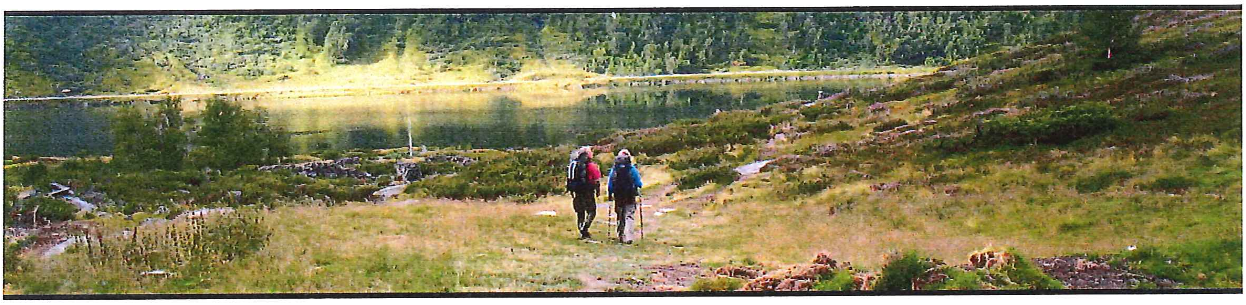
APPENDIX 1:

Study information and informed consent (**Paper I and II**)

Kan1
Kartlegging aktivitet Norge



Forespørsel om deltakelse i Kan1

– en **kartleggingsundersøkelse** av fysisk aktivitet og fysisk form blant **voksne** og **eldre**

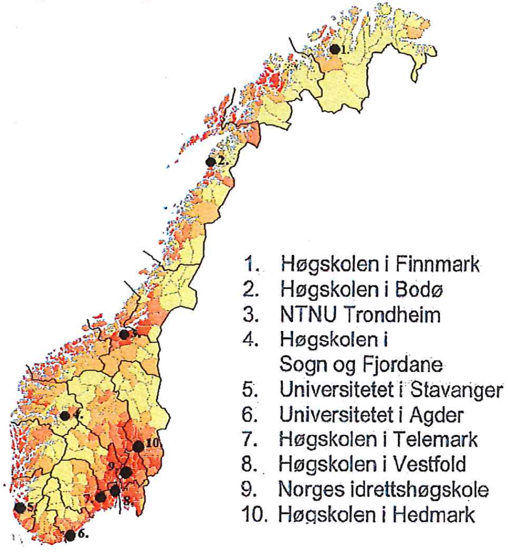
NTNU
Samfunnsforskning AS

NORGES IDRETTSHØGSKOLE

Helsedirektoratet

Hva er Kan1-undersøkelsen?

Kan1 er en landsomfattende kartlegging av befolkningens aktivitetsnivå og fysiske form. Vi har i dag ikke tilstrekkelig informasjon på dette feltet til å kunne beskrive utviklingstrekk i befolkningsgrupper og geografiske områder og forskjeller mellom dem. Denne undersøkelsen er ett ledd i Helsedirektoratets Handlingsplan for fysisk aktivitet, hvor et av hovedmålene er å etablere et system for kartlegging av det fysiske aktivitetsnivået i befolkningen. Undersøkelsen gjennomføres over hele landet i løpet av 2008 og 2009 og utføres av følgende høgskoler og universiteter:



1. Høgskolen i Finnmark
2. Høgskolen i Bodø
3. NTNU Trondheim
4. Høgskolen i Sogn og Fjordane
5. Universitetet i Stavanger
6. Universitetet i Agder
7. Høgskolen i Telemark
8. Høgskolen i Vestfold
9. Norges idrettshøgskole
10. Høgskolen i Hedmark

Hva innebærer deltakelse i undersøkelsen for deg?

Deltakelse i undersøkelsen innebærer at du svarer på et spørreskjema og går med en aktivitetsmåler i syv dager. Aktivitetsmåleren er et lite og lett apparat som bæres i et elastisk belte rundt livet (se bilder neste side). Du går med måleren i 7 dager og returnerer den deretter sammen med spørreskjemaet i vedlagt returkonvolutt (Fase 1). I etterkant av Fase 1 vil om lag ¼ av deltakerne bli tilfeldig trukket ut og invitert til å gjennomføre en tilleggsundersøkelse av fysisk form (Fase 2). Du kan delta i den første delen av undersøkelsen, og si nei til videre deltakelse.

KAN du delta?

Velger du å delta i Kan1-undersøkelsen bidrar du med viktig og ny kunnskap om aktivitetsnivå og fysisk form i befolkningen.

Alle kan delta, uansett om man ser på seg selv som fysisk aktiv eller ikke.

Hensikten med undersøkelsen er å kartlegge et utvalg som representerer hele befolkningen, ikke bare den delen som er mest aktiv.

Fordeler og ulemper

Ved deltakelse i undersøkelsen vil du i etterkant motta en detaljert tilbakemelding på eget aktivitetsnivå. Du vil blant annet se hvorvidt du oppfyller Helsedirektoratets anbefalinger for fysisk aktivitet. Dersom du blir invitert til videre deltakelse i Fase 2, vil du få tilbakemelding på egen fysisk form. Test av fysisk form i Fase 2 kan påføre deltakere noe ubehag, da man skal utføre enkelte øvelser med høy intensitet.

Hva skjer med informasjonen om deg?

All informasjon som samles inn om deg, vil bli behandlet i henhold til gjeldende lover og forskrifter. Alle medarbeidere involvert i undersøkelsen har taushetsplikt, og opplysningene som samles inn, vil kun bli brukt til godkjente forskningsformål. Se avsnittet om personvern på neste side for mer informasjon.

Frivillig deltakelse

Det er frivillig å delta i undersøkelsen. Du kan når som helst trekke deg uten å oppgi noen grunn. Dersom du ønsker å delta, undertegner du samtykkeerklæringen på siste side.

Kriterier for deltakelse

Kriterier for deltakelse er at man er over 20 år, bor i Norge og er norsk statsborger.

Tidsplan

I perioden april til november 2008 sendes spørreskjema og aktivitetsmåler til deltakeren. Denne delen av undersøkelsen skjer kun per post og kalles Fase 1. Et tilfeldig utvalg av deltakerne i Fase 1 (omtrent ¼) vil bli invitert til en undersøkelse av fysisk form (Fase 2). Fase 2 vil finne sted to til seks måneder etter hovedundersøkelsen. Det er fullt mulig å si nei til deltakelse i Fase 2, selv om man har deltatt i Fase 1.

Mulige bivirkninger

Det er ingen kjente bivirkninger ved deltakelse i undersøkelsen. Test av fysisk form i Fase 2 kan påføre deltaker noe ubehag idet man skal utføre enkelte øvelser med høy intensitet. Eventuelle reiseutgifter for deltakere som blir invitert til deltakelse i Fase 2, vil bli dekket av undersøkelsen.

Personvern

Undersøkelsen er godkjent av Regional komité for medisinsk og helsefaglig forskningsetikk Helseregion Sør avdeling B, REK Sør B. Undersøkelsen er tilrådd av personvernombudet for forskning, Norsk samfunnsvitenskapelig datatjeneste A/S.

Opplysninger som registreres om deg, er personalia som alder, kjønn, sivil status og etnisitet, i tillegg til opplysninger om blant annet aktivitet, kosthold og helse. Du kan være trygg på at informasjonen du bidrar med til undersøkelsen, vil bli behandlet med respekt for personvern og privatliv, og i samsvar med lover og forskrifter.

Innsamlede opplysninger oppbevares slik at navn er erstattet med en kode som viser til en atskilt navneliste. Det er kun autorisert personell knyttet til prosjektet som har adgang til navnelisten og som kan finne tilbake til deg. Det vil ikke være mulig å identifisere deg i resultatene av undersøkelsen når disse publiseres.

Rett til innsyn og sletting av opplysninger om deg og sletting av prøver

Hvis du sier ja til å delta i undersøkelsen, har du rett til å få innsyn i hvilke opplysninger som er registrert om deg. Du har videre rett til å få korrigert eventuelle feil i de opplysningene vi har registrert. Dersom du trekker deg fra undersøkelsen, kan du kreve å få slettet innsamlede prøver og opplysninger, med mindre opplysningene allerede er inngått i analyser eller brukt i vitenskapelige publikasjoner.

Det kan bli aktuelt å innhente opplysninger om deg fra nasjonale helseregistre: Skade-, kreft-, dødsårsaks-, og reseptregisteret. Vi ber om din tillatelse til å innhente tilleggsinformasjon fra de nevnte registre. Alle innsamlede opplysninger anonymiseres senest innen 31.12.2020, med mindre vi innen da har kontaktet deg med forespørsel om noe annet.

Økonomi og Helsedirektoratets rolle

Undersøkelsen er finansiert og initiert av Helsedirektoratet.

Bilde 1 og 2. Aktivitetsmåleren i bruk

Kan1

Samtykke til deltakelse i undersøkelsen

Dette eksemplaret underskrives og returneres i vedlagt svarkonvolutt.
Den returnerte samtykkeerklæringen vil bli oppbevart på ett nedlåst sted.

Jeg er villig til å delta i undersøkelsen

Vennligst fyll ut opplysningene nedenfor:
(skriv tydelig, helst med blokkbokstaver)

Fornavn:

....

Etternavn:

....

....
(Signer her)

Jeg bekrefter å ha gitt informasjon om undersøkelsen

Sigmund Anderssen
....
Professor Sigmund Alfred Anderssen
Prosjektleder
Seksjon for idrettsmedisin
Norges idrettshøgskole

kartlegging **aktivitet** Norge
2008

APPENDIX 2:

Informed consent (**Paper III and IV**)

SAMTYKKEERKLÆRING

Jeg erklærer herved at jeg er villig til å delta i prosjektet " STYRKE 65+". Hensikten med prosjektet er blitt meg forklart.

Etter de rettigheter som Etisk Komitè anbefaler for slike undersøkelser. Prosjektet i sin helhet er godkjent av Datatilsynet og Etisk Komitè.

Jeg kan trekke meg fra undersøkelsen når det måtte passe meg uten å oppgi grunn.

Kristiansand, den ....

Navn: ....

APPENDIX 3:

Questionnaire (**Paper III and IV**)

*Referanse nummer:*________

" STYRKE 65+"

Dette spørreskjemaet er til Dem som er med i undersøkelsen «STYRKE 65+».

Navn og informasjon om den enkelte blir behandlet fortrolig.

Materiale fra undersøkelsen offentliggjøres/publiseres anonymt.

Kryss av på denne måten:
Ja _X_ Nei ___

Ved rettelse kan De bruke korrekturlakk, eller markere tydelig at det er feil.

Vennligst skriv med STORE bokstaver der hvor det er nødvendig.

SPØRRESKJEMA

Om Dem selv:

1. **Hvor gammel er De?** Alder ____________

2. **Kjønn** Kvinne ____ Mann ____

3. **Høyde (cm)** ____

4. **Kroppsvekt (kg)** ____

5. **Hva er Deres sivilstand nå?** *(Sett et kryss)*
Gift ____
Ugift ____
Enke/enkemann ____
Skilt ____
Separert ____

Dersom De ikke er gift:
Er du samboer? Ja ____ Nei ____
Bor De alene? Ja ____ Nei ____

Utdanning:

6. **Hvilken utdanning er den høyeste De har fullført?**

Grunnskole mindre enn 7 år ____
Grunnskole, framhaldsskole, 7-10 år ____

Realskole, middelskole, yrkesskole,
1-2-årig videregående ____
Gymnas, 3-årig videregående skole ____
Høgskole/universitet mindre enn 4 år ____
Høgskole/universitet, 4 år eller mer ____

Yrke:

7. **Hvilken type næring arbeidet de innenfor i Deres yrkesaktive karriere?**

	Hovedyrke	Biyrke
Jordbruk, skogbruk, fiske, fangst	____	____
Oljeutvinning, bergverk	____	____
Byggevirksomhet	____	____
Varehandel, hotell, restaurantvirksomhet	____	____
Transport, lagring, post, Telekommunikasjon	____	____
Bank, finansiering, forsikring, eiendomsdrift, forretningsmessig tjenesteyting	____	____
Offentlig tjenesteyting, helse og sosial	____	____
Offentlig tjenesteyting, undervisning	____	____
Offentlig tjenesteyting, annet	____	____
Annet	____	____

Helsemessige forhold:

8. **Hvordan vurderer De Deres helse?**

Meget God ____
God ____
Verken god eller dårlig ____
Dårlig ____
Meget dårlig ____

9. **Hvordan tror De at De vil vurdere Deres helse om ett år?**

Mye bedre enn nå ____
Litt bedre enn nå ____
Omtrent som nå ____
Litt dårligere enn nå ____
Mye dårligere enn nå ____

10. **Har De noen gang hatt/har en eller flere av følgende sykdommer/lidelser?**

Angina Pectoris ____
Hjerteinfarkt ____ (*når?*)
Hjerneslag ____ (*når?*)
Behandles for høyt blodtrykk ____
Beinskjørhet ____
Beinbrudd ____ (*når?*)
Muskel- og skjelettlidelser ____
Diabetes
Astma/allergi ____
Leversykdom ____
Lungelidelse ____ (*hvilken?*)
Angst/depresjon ____
Andre kroniske lidelser ____ (*hvilke?*)
Annen bevegelseshemning som er Dem til besvær i hverdagen ____ (*hvilken?*)

Medisinering/rusmidler:

11. **Er De avhengig av daglig medisinering?** Ja ____ Nei ____

12. **Røyker De?** Ja ____ Nei ____

13. **Snuser De?** Ja ____ Nei ____

Aktiviteter knyttet til dagliglivet (ADL-funksjon):

14. **Kan gjennomføre daglige aktiviteter som å:** *(ett kryss per aktivitet)*:

Spise, drikke
Uavhengig av andre og lett ___
Uavhengig, men med noen problemer ___
Avhengig, eller trenger veiledning/assistanse ___

Vaske ansikt, hender	*Uavhengig av andre og lett___* *Uavhengig, men med noen problemer ___* *Avhengig, eller trenger veiledning/assistanse___*
Gå på toalettet	*Uavhengig av andre og lett___* *Uavhengig, men med noen problemer ___* *Avhengig, eller trenger veiledning/assistanse___*
Reise seg opp fra stol	*Uavhengig av andre og lett___* *Uavhengig, men med noen problemer ___* *Avhengig, eller trenger veiledning/assistanse___*
Komme opp og ut av sengen	*Uavhengig av andre og lett___* *Uavhengig, men med noen problemer ___* *Avhengig, eller trenger veiledning/assistanse___*
Bevege seg inne i hus	*Uavhengig av andre og lett___* *Uavhengig, men med noen problemer ___* *Avhengig, eller trenger veiledning/assistanse___*
Kle på seg	*Uavhengig av andre og lett___* *Uavhengig, men med noen problemer ___* *Avhengig, eller trenger veiledning/assistanse___*
Gjøre lett husrengjøring	*Uavhengig av andre og lett___* *Uavhengig, men med noen problemer ___* *Avhengig, eller trenger veiledning/assistanse___*
Vaske seg selv fra "topp til tå"	*Uavhengig av andre og lett___* *Uavhengig, men med noen problemer ___* *Avhengig, eller trenger veiledning/assistans*
Bevege seg utendørs på flatt underlag	*Uavhengig av andre og lett___* *Uavhengig, men med noen problemer ___* *Avhengig, eller trenger veiledning/assistanse___*

Tilberede middag
*Uavhengig av andre og lett*___
Uavhengig, men med noen problemer ___
*Avhengig, eller trenger veiledning/assistanse*___

Tilberede frokost, lunsj
*Uavhengig av andre og lett*___
Uavhengig, men med noen problemer ___
*Avhengig, eller trenger veiledning/assistanse*___

Gå opp og ned trapper
*Uavhengig av andre og lett*___
Uavhengig, men med noen problemer ___
*Avhengig, eller trenger veiledning/assistanse*___

Re sengen
*Uavhengig av andre og lett*___
Uavhengig, men med noen problemer ___
*Avhengig, eller trenger veiledning/assistanse*___

Stelle egne føtter og negler
*Uavhengig av andre og lett*___
Uavhengig, men med noen problemer ___
*Avhengig, eller trenger veiledning/assistanse*___

Vaske og stryke klær
*Uavhengig av andre og lett*___
Uavhengig, men med noen problemer ___
*Avhengig, eller trenger veiledning/assistanse*___

Handle
*Uavhengig av andre og lett*___
Uavhengig, men med noen problemer ___
*Avhengig, eller trenger veiledning/assistanse*___

Gjøre tung husrengjøring
*Uavhengig av andre og lett*___
Uavhengig, men med noen problemer ___
*Avhengig, eller trenger veiledning/assistanse*___

Fysisk aktivitet:

15. **Hvilket aktivitetsnivå ligger De på:**
(sett kun et kryss)

Nesten aldri fysisk aktiv	____
Mest sitting, lett gange, lett hagestell, lett husarbeid	____
Lett fysisk aktivitet som spaserturer, sykling, fisking, dansing, litt tyngre hagestell og husarbeid	____
Moderat fysisk aktivitet (1-2 ganger i uken) som rask gange, jogg, "tøffere" sykling, svømming, gymnastiske aktiviteter, tungt hage- og husarbeid	____
Middels fysisk aktivitet (3-6 ganger i uken) som tennis, svømming og jogging	____
Hard eller veldig hard fysisk aktivitet (daglige treningsdoser) som løp, skigåing, fysisk krevende hobby som eks. fjellklatring	____

16. **Sett kryss ved den påstand / de påstander som passer best for Dem:**
(mer enn et kryss kan settes inn)

Driver fysisk aktivitet mest i sammen med andre	____
Driver fysisk aktivitet mest alene	____
Deltar i organisert fysisk aktivitet	____
Driver med ikke-organisert fysisk aktivitet	____

Driver andre former for fritids-
aktiviteter/hobbyer, som jakt, fiske,
håndverk, håndarbeid, kortspill, sjakk ____

17. **Sett et kryss ved den påstand som passer best for Dem av følgende tre:**

Har alltid drevet med fysisk aktivitet/idrett ____

Har vært aktiv tidligere, hatt en passiv
periode, og så begynt med fysisk aktivitet/
idrett ____

Har kun de siste årene drevet med fysisk
aktivitet/idrett ____

18. **Hvordan har din fysiske aktivitet vært det siste året?**
(Tenk deg et ukentlig gjennomsnitt for året)

<u>Antall timer per uke:</u>	Ingen	Under 1	1-2	3 og mer
Lett aktivitet *(ikke svett/andpusten)*	____	____	____	____
Hard fysisk aktivitet *(svett/andpusten)*	____	____	____	____

19. **Verdens helseorganisasjon anbefaler at man til sammen driver minst <u>30 minutters</u> moderat eller intens fysisk aktivitet så å si hver dag. Vil De si at De holder dette aktivitetsnivået?**
(sett kun et kryss)

Ja ____

Nei ____

Vet ikke ____

20. **Hva er den største hindringen til at De ikke er mer fysisk aktiv?**

Ingen hindring ____
Kriminalitet ____
Lite/dårlig gang-sykkelvei ____
Redd for å falle ____
Har ingen å drive fysisk aktivitet med ____
Ikke skogsterreng i nærheten ____
Sykdom/fysiske begrensninger ____

TUSEN TAKK FOR HJELPEN☺

Mvh Hilde Lohne-Seiler

Høgskolelektor, Prosjektleder
Høgskolen i Agder
Avdeling for helse- og idrettsfag

APPENDIX 4:

Verification; the Regional Committee for Medical and Health Research Ethics and the Norwegian Social Science Data Services AS (**Paper I and II**).

UNIVERSITETET I OSLO
DET MEDISINSKE FAKULTET

Professor Dr. scient Sigmund Alfred Anderssen
Norges idrettshøgskole
Pb. 4014 Ullevål Stadion
0806 Oslo

Regional komité for medisinsk og helsefaglig forskningsetikk Sør-Øst B (REK Sør-Øst B)
Postboks 1130 Blindern
NO-0318 Oslo

Telefon: 22 85 06 70
Telefaks: 22 85 05 90
E-post: jorunn.lindholt@medisin.uio.no
Nettadresse: www.etikkom.no

Dato: 11.02.08
Deres ref.:
Vår ref.: S-08046b

S-08046b Kartlegging av fysisk aktivitetsnivå, helserelatert fysisk form og determinanter for fysisk aktivitet hos voksne og eldre i Norge [6.2008.142]

Søknad mottatt 08.01.08 med følgende vedlegg: Protokoll; informasjonsskriv med samtykkeerklæring; spørreskjema; følgebrev til REK Sør-Øst datert 7. januar 2008.

Komiteen behandlet søknaden i sitt møte den 31. januar 2008. Prosjektet er vurdert etter lov om behandling av etikk og redelighet i forskning av 30. juni 2006, jfr. Kunnskapsdepartementets forskrift av 8. juni 2007 og retningslinjer av 27. juni 2007 for de regionale komiteer for medisinsk og helsefaglig forskningsetikk.

Forskningsetisk vurdering
Denne studien er todelt, og vil kartlegge status for fysisk aktivitetsnivå, determinanter for fysisk aktivitet, fysisk form og variabler relatert til fysisk form blant den voksne og eldre delen av den norske befolkningen. Komiteen ser ingen etiske betenkeligheter ved denne studien, forutsatt at den direkte målingen av fysisk form/aerob kapasitet i undersøkelsens Del 2 gjennomføres slik den er beskrevet i prosjektbeskrivelsen (dvs. at screening foretas før testen og at akuttmedisinsk hjelp er tilgjengelig under testen).

Vi ber imidlertid prosjektgruppen om å revurdere utvalgsstørrelsen som ligger til grunn for undersøkelsens Del 1. Styrkeberegningene som ligger til grunn for Del 1 (og for Del 2) synes å hvile på et solid grunnlag. Vi ser imidlertid at prosjektgruppen forventer at hele 2/3 deler av de 6000 personene som blir forespurt sier seg villige til å delta i del 1 av studien. Dette synes svært optimistisk med utgangspunkt i at prosjektgruppen henviser til at responsraten ved nylig gjennomførte landsdekkende undersøkelser i regi av FHI har vært på om lag 50 %. Det at deltagerne bes om å bære et akselerometer i en periode på syv dager vil nok neppe bidra til å øke responsraten. Komiteen ønsker en refleksjon omkring hvorvidt dette er realistisk.

I prosjektets Del 2 foreslås det å utelate aldersgruppen 20-30 år pga. økonomiske hensyn. Et av prosjektets mer langsiktige målsetninger er å studere utviklingstrender innen ulike aldersgrupper, gjennom å gjenta undersøkelsen med jevne mellomrom. At den yngste aldersgruppen utelates er bekymringsfullt da dette vil gjøre det problematisk å studere endringer i de yngste aldergruppene over tid. Siden potensialet for forebygging sannsynligvis er størst i nettopp de yngste aldersgruppene, vil utelatelsen redusere undersøkelsens verdi som redskap for forebygging. Vi ber prosjektgruppen om å vurdere på nytt om ikke også denne aldersgruppen bør inkluderes.

Informasjonsskriv/samtykkeerklæring
1. Informasjonskrivet må påføres logo.
2. I andre avsnitt på første side må det informeres at testen av fysisk form kan påføre enkelte noe ubehag da deler av denne skal utføres under høy intensitet (flytt dette fram fra kapittel A).

3. Det må opplyses om at prosjektet er godkjent av Regional komité for medisinsk og helsefaglig forskningsetikk Helseregion Sør avdeling B, REK Sør B.
4. I kapittel A og B kan begrepsbruken være litt vanskelig å forstå. "Akselerometer" foreslås byttet ut med "aktivitetsmåler". Videre bør det forklares hva som ligger i at "eventuell utgifter for deltakerne i undersøkelsens del 2 vil bli dekket".
5. Dato for sletting av data/kode må angis.
6. "Dette vil ikke få konsekvenser for din videre må behandling" må utgå da personene som deltar i dette prosjektet ikke er til behandling som er knyttet til deltakelsen.

Vedtak
Prosjektet godkjennes under forutsetning av at de merknadene som er anført ovenfor blir innarbeidet før prosjektet settes i gang. Revidert informasjonsskriv og samtykkeerklæring må sendes komiteen til orientering.

Komiteens avgjørelse var enstemmig.

Komiteens vedtak kan påklages (jfr. Forvaltningslovens § 28) til Den nasjonale forskningsetiske komité for medisin og helsefag. Klagen skal sendes til REK Sør-Øst B (jfr. Forvaltingslovens § 32). Klagefristen er tre uker fra den dagen du mottar dette brevet (jfr. Forvaltningslovens § 29). Det bes presisert hvilke vedtak/vilkår som påklages og den eller de endringer som ønskes. Se informasjon om klageadgang og partsinnsynsrett på http://www.etikkom.no/REK/klage

Med vennlig hilsen

Tor Norseth
Leder

Jorunn Lindholt
Jorunn Lindholt
Sekretær

UNIVERSITETET I OSLO
DET MEDISINSKE FAKULTET

Professor Dr. scient Sigmund Alfred Anderssen
Norges idrettshøgskole
Pb. 4014 Ullevål Stadion
0806 Oslo

Regional komité for medisinsk og helsefaglig
forskningsetikk Sør-Øst B (REK Sør-Øst B)
Postboks 1130 Blindern
NO-0318 Oslo

Telefon: 22 85 06 70
Telefaks: 22 85 05 90
E-post: juliannk@medisin.uio.no
Nettadresse: www.etikkom.no

Dato: 29.04.08
Deres ref.:
Vår ref.: S-08046b

S-08046b Kartlegging av fysisk aktivitetsnivå, helserelatert fysisk form og determinanter for fysisk aktivitet hos voksne og eldre i Norge [6.2008.142]

Vi viser til brev datert 18.03.08 vedlagt revidert informasjonsskriv og spørreskjema.

Komiteen tar revidert informasjonsskriv og spørreskjema til orientering.

Vi ønsker lykke til med prosjektet!

Med vennlig hilsen

Tor Norseth
Leder

Julianne Krohn-Hansen
Sekretær

Norsk samfunnsvitenskapelig datatjeneste AS
NORWEGIAN SOCIAL SCIENCE DATA SERVICES

NSD
Harald Hårfagres gate 29
N-5007 Bergen
Norway
Tel: +47-55 58 21 17
Fax: +47-55 58 96 50
nsd@nsd.uib.no
www.nsd.uib.no
Org.nr. 985 321 884

Sigmund A. Anderssen
Seksjon for idrettsmedisinske fag
Norges idrettshøgskole
Postboks 4014 Ullevål Stadion
0806 OSLO

Vår dato: 24.04.2008 Vår ref: 18886 / 2 / SF Deres dato: Deres ref:

TILRÅDING AV BEHANDLING AV PERSONOPPLYSNINGER

Vi viser til melding om behandling av personopplysninger, mottatt 14.03.2008. Meldingen gjelder prosjektet:

18886	*Kartlegging av fysisk aktivitetsnivå, helserelatert fysisk form og determinanter for fysisk aktivitet hos voksne og eldre i Norge*
Behandlingsansvarlig	*Norges idrettshøgskole, ved institusjonens øverste leder*
Daglig ansvarlig	*Sigmund A. Anderssen*

Personvernombudet har vurdert prosjektet, og finner at behandlingen av personopplysninger vil være regulert av § 7-27 i personopplysningsforskriften. Personvernombudet tilrår at prosjektet gjennomføres.

Personvernombudets tilråding forutsetter at prosjektet gjennomføres i tråd med opplysningene gitt i meldeskjemaet, korrespondanse med ombudet, eventuelle kommentarer samt personopplysningsloven/-helseregisterloven med forskrifter. Behandlingen av personopplysninger kan settes i gang.

Det gjøres oppmerksom på at det skal gis ny melding dersom behandlingen endres i forhold til de opplysninger som ligger til grunn for personvernombudets vurdering. Endringsmeldinger gis via et eget skjema, http://www.nsd.uib.no/personvern/forsk_stud/skjema.html. Det skal også gis melding etter tre år dersom prosjektet fortsatt pågår. Meldinger skal skje skriftlig til ombudet.

Personvernombudet har lagt ut opplysninger om prosjektet i en offentlig database, http://www.nsd.uib.no/personvern/prosjektoversikt.jsp.

Personvernombudet vil ved prosjektets avslutning, 31.12.2020, rette en henvendelse angående status for behandlingen av personopplysninger.

Vennlig hilsen

Bjørn Henrichsen

Sølve Fauskevåg

Kontaktperson: Sølve Fauskevåg tlf: 55 58 25 83
Vedlegg: Prosjektvurdering

Prosjektvurdering - Kommentar

18886

BAKGRUNN
Prosjektet er et samarbeid mellom institusjonene:

- Norges idrettshøgskole
- Høgskolene i Finnmark, Bodø, Sogn og Fjordane, Vestfold, Telemark og Hedmark
- Universitetene i Stavanger og Agder, samt NTNU

Norges idrettshøgskole (NIH) er koordinerende aktør og databehandlingsansvarlig for prosjektet. Prosjektleder, ved NIH, er daglig ansvarlig. Det inngås databehandleravtaler mellom samarbeidspartene i henhold til personopplysningsloven § 15.

FORMÅL
Formålet med undersøkelsen er å øke kunnskapen om fysisk aktivitetsnivå, fysiske aktivitetsvaner, samt determinanter for fysisk aktivitet i den voksne delen av den norske befolkningen.

Undersøkelsen iverksettes på initiativ fra Sosial- og helsedirektoratet. Det kan bli aktuelt å gjennomføre oppfølgingsundersøkelser om fem og/eller ti år, og det kan være aktuelt å utvide datagrunnlaget med registerdata. Eventuelle nye oppfølginger og/eller utvidelser meldes ombudet i god tid før iverksetting.

UTVALG, INFORMASJON OG SAMTYKKE
Utvalget er et tilfeldig utvalg av cirka 8000 personer. Utvalget trekkes fra Folkeregisteret og av EDB Business Partner basert på tillatelse fra Skattedirektoratet.

Utvalget sendes informasjonsskriv og kan samtykke skriftlig til deltakelse.

DATAMATERIALET
Datamaterialet innhentes ved hjelp av spørreskjema, aktivitetsmåler og fysiske tester og målinger. Datamaterialet inneholder blant annet navn, personnummer, kjønn, alder, etnisk bakgrunn, yrke, inntekt og utdanningsnivå, kommune, røyking og snus, medlemskap i idrettslag/foreninger, kosthold og bruk av TV og PC, fysisk form (balanse, styrke, bevegelighet og koordinasjon), høyde, vekt, livvidde, hoftevidde, kroppssammensetning, blodtrykk samt resultatene fra aktivitetsmåler (akselerometer) som utvalget skal gå med i syv dager.

REGISTRERING, OPPBEVARING OG UTLEVERING
Navn, fødselsår, adresse, fødekommune og fødeland, sivilstatus og antall barn trekkes fra Folkeregisteret. Informasjonsskriv sendes det trekte utvalget. Det kan gjøres en purring til personer som ikke har svart på første forespørsel.

Alle registrerte opplysninger tilknyttet den delen av utvalget som ikke samtykker, anonymiseres umiddelbart etter at svarfristen på purringen har utløpt.

Prosjektleder vil ha tilgang til hele datamaterialet. De lokale koordinatorene har tilgang til den delen av datamaterialet som de er ansvarlige for å samle inn. Prosjektets styringsgruppe vil ikke ha tilgang til datamaterialet.

Prosjektet forventes avsluttet med rapport 31.01.2009. Datamaterialet skal deretter oppbevares til 31.12.2020 med tanke på eventuelle oppfølgings- eller utvidede undersøkelser. Innen 31.12.2020 anonymiseres datamaterialet. Anonymisering innebærer at direkte og indirekte personidentifiserende opplysninger slettes eller omskrives (grovkategoriseres), samt at koblingsnøkkel slettes.

ANDRE TILLATELSER
Prosjektet er godkjent av Regional komité for medisinsk forskningsetikk Midt-Norge (REKs ref. S-08046b).

Skatteetaten har gitt tillatelse til å trekke utvalget inkludert noen bakgrunnsopplysninger fra Folkeregisteret (Skatteetatens ref. 2008/167522 /SKDRESF/GTE /341).

KOMMENTAR
Personvernombudet finner at prosjektet kan gjennomføres med hjemmel i personopplysningsloven (pol) §§ 8, første ledd og 9 a), samtykke.

Informasjonsskrivet per 23.04.2008 er godt utformet og redegjør for alle sider ved prosjektet forutsatt at dato for anonymisering av data tilføyes, jf. e-post samme dag.

Trekking og førstegangskontakt med utvalget kan hjemles i personopplysningsloven §§ 8 d) og 9 h). Det vises til at undersøkelsen er på oppdrag fra Sosial- og helsedirektoratet og tar sikte på å fremskaffe ny representativ kunnskap om aktivitet og helse. Trekking og kontakt med et representativt utvalg kan vanskelig gjøres på mer skånsom måte enn via Folkeregisteret. Ulempene for de registrerte er minimale da de informeres om trekkingen, og registrerte opplysninger anonymiseres umiddelbart for de som ikke samtykker innen svarfrist for purringen har utløpt.

APPENDIX 5:

Verification; the Regional Committee for Medical and Health Research Ethics and the Norwegian Social Science Data Services AS (**Paper III and IV**).

REGIONAL KOMITE FOR MEDISINSK FORSKNINGSETIKK

Helseregion II

Høgskolelektor
Hilde Lohne Seiler
Høgskolen i Agder
Avdeling for idrettsfag
Serviceboks 422
4604 Kristiansand

Deres ref.: 8. februar 2000 **Vår ref.:** S-00005 **Dato:** 16.02.00

Betydning av styrketrening for eldre i forhold til det å kunne opprettholde/ forbedre ADL (activity of daily living)-funksjon
Revidert informasjon til forsøkspersonene

Vi takker for revidert informasjonsskriv.

Komiteen finner at det er tatt hensyn til komiteens merknader i brev av 04.02.00.

Komiteen vil likevel gi noen merknader til det reviderte informasjonsskrivet, da den finner at det er behov for noen presiseringer og endringer.

Når det gjelder siste setning (og avsnitt) på side 2, er komiteen i tvil om tilbudet om tilrettelagt fysisk aktivitet gjelder alle deltakerne i prosjektet i betydningen "alle som har svart på spørreskjema" eller om det bare gjelder de som er trukket ut til fysisk aktivitet og kontrollgruppe. Det bør presiseres.

I første avsnitt på side 3 i informasjonen vil komiteen be om at setningen "Jeg oppfordrer Dem til å ----" endres til "De oppfordres til å -----"

Komiteen vil be prosjektleder se nærmere på fjerde avsnitt på side 3 i informasjonen. Komiteen vil foreslå at første setning får følgende ordlyd: "Det er likevel et begrenset antall av dere som svarer Ja, som vil bli invitert til å bli med på andre del av undersøkelsen". Neste setning virker nokså ugjennomsiktig. Er det f.eks. rimelig å kalle et begrenset antall deltakere et kriterium? Vi vil anbefale at setningen omarbeides. Det bør også fremgå på hvilken måte de som inviteres til andre del, vil bli kontaktet, om det vil skje skriftlig eller på annen måte.

Komiteen går ut i fra at prosjektleder tar det som er sagt ovenfor i betraktning, og tilrår at prosjektet gjennomføres.

Vi ønsker lykke til med prosjektet.

Med vennlig hilsen

Sigurd Nitter-Hauge (sign)
professor dr.med.
leder

Ola P Hole

Ola P. Hole
avdelingsleder
sekretær

Norsk samfunnsvitenskapelig datatjeneste
NORWEGIAN SOCIAL SCIENCE DATA SERVICES

NSD

Hans Holmboesgt. 22
N-5007 Bergen
Norway
Tel: +47/ 55 58 21 17
Fax: +47/ 55 58 96 50
E-mail: nsd@nsd.uib.no
http://www.uib.no/nsd

Hilde Lohne Seiler
Høgskolen i Agder
Avdeling for helse og idrettsfag
Servicebokes 422
4604 KRISTIANSAND

Dato: 26.01.00 Vår ref: 200000031 EWJ/EH Deres dato: 18.01.00 Deres ref:

FORSKNINGSPROSJEKT SOM OMFATTES AV KONSESJONSPLIKT

7028 Betydningen av styrketrening for eldre i forhold til det å kunne opprettholde/forbedre ADL-funksjon (activity of daily living)

Vi viser til mottatt meldeskjema, 18.01.00, angående konsesjon for ovennevnte forskningsprosjekt. Prosjektet utløser konsesjonsplikt i henhold til Lov om personregistre m.m. § 9, første ledd.

Saken er behandlet ved Datafaglig sekretariat og oversendt Datatilsynet 26.01.00 for endelig avgjørelse. Datafaglig sekretariat har anbefalt at prosjektet gis konsesjon. Datatilsynet opplyser overfor Datafaglig sekretariat at saksbehandlingstiden er ca. 4 uker. Prosjektet kan ikke startes opp før du har mottatt konsesjon fra Datatilsynet.

Dersom noe er uklart ber vi deg kontakte oss, gjerne over telefon.

Kopi av innstilling følger vedlagt.

Vennlig hilsen
Datafaglig sekretariat

Vigdis Kvall
Vigdis Kvalheim

Ewelyn Jordal
Ewelyn Jordal

Kontaktperson: Ewelyn Jordal Tlf. 55 58 33 48

Innstilling til Datatilsynet

Forskningsprosjekt

Dato sendt fra
Datafaglig sekretariat:: 26.01.00

Saksbehandler Ewelyn Jordal

Prosjektleder:

Hilde Lohne Seiler

Høgskolen i Agder
Avdeling for helse og idrettsfag
Serviceboks 422
4604 KRISTIANSAND

Prosjektnr.: 7028

Prosjekttittel:

Betydningen av styrketrening for eldre i forhold til det å kunne opprettholde/forbedre ADL-funksjon (activity of daily living)

Formålet med dette prosjektet er bl.a. å se på effekten av høy-intensiv styrketrening og sentral stimulering på faktorer som muskulær styrke og sentrale funksjoner, målt som "finer/fottapping", gangfrekvens, recovery time, reaksjonstid, statisk og dynamisk balanse hos mennesker i alderen 67--74 år og eldre enn 85 år. Videre vil hensikten med prosjektet være å se på hvilken overføringsverdi en eventuell effekt av høyintensiv styrketrening og sentral stimulering har på de motoriske aktiviteter som er knyttet til mestring av dagliglivets gjøremål, også kalt ADL-funksjon. I avslutningsfasen vil det bli fokusert på implementering av re reproduserbart treningskonsept hvor målet er å forbedre eldres ADL-funksjon.

Deltagerne i undersøkelsen er et geografisk utvalg av 400 kvinner og menn i aldersgruppene 67-74 år og over 85 år. Utvalget trekkes fra telefonkatalogen. Det er adresseringsforetaket DM-huset som trekker utvalget og leverer listen til prosjektleder. Det er således prosjektleder som oppretter første gangs kontakt ved utsending av spørreskjema.

Alle opplysninger innhentes fra respondentene selv ved spørreskjema i screeningfasen. Se vedlagt skjema.

Det vil så bli trukket ut 70 personer som skal inngå i en intervensjonsfase. Det vil her bli foretatt testing og innhentes opplysninger gjennom medisinsk undersøkelse (blodtrykk, hvile- og arbeids EKG, måling av høyde og vekt) og laboratoriebaserte undersøkelser (måling av fysisk kapasitet), muskelstyrke (ErgoPower m/EMG), sentrale funksjoner som "finger-flikking", gangfrekvens, recovery-time, reaksjonstid, statisk og dynamisk balanse, ganghastighet, gangfunksjon (videoanalyse) og ADL-funksjon.

Gruppe I skal testes for effekter av høy-intensiv styrketrening. Gruppe II skal studeres mhp effekter av sentral stimulering. Gruppe III er en kontrollgruppe.
I intervensjonsfasen foretas det testing før start og etter 6 uker og 3 måneder for begge grupper. Opplysningene blir registrert på skjema og deretter edb-registrert. Tester tatt opp på video blir kodet og edb-registrert. Vi viser til vedlagte registreringsskjema og testskjema.

Det blir sendt ut informasjonsskriv med spørreskjema, se vedlegg 3. Det gis svært god og utfyllende informasjon om hva gjennomføringen av hele prosjektet medfører, men at man i første omgang kun skal besvare spørreskjema. Man blir så opplyst om at retur av spørreskjema medfører at man kan bli kontaktet igjen med spørsmål om å være med, dersom man ønsker det. Det opplyses om at deltagelse er frivillig, at man kan trekke seg og få personopplysninger slettet og at persondata blir anonymisert for de som bare deltar i spørreskjemaundersøkelsen. Det opplyses om at de som blir med videre, vil få tilleggsinformasjon. Denne tar form av standard taushets- og samtykkeerklæring, hvor det bl.a. innhentes samtykke til å arkivere data i personidentifiserbar form etter prosjektslutt. Se vedlegg 4.

Prosjektet er lagt fram for Regional komité for medisinsk forskningsetikk. Datafaglig sekretariat forutsetter at prosjektet gjennomføres etter tilråding fra komitéen.

Prosjektleder opplyser at det er ønskelig å oppbevare datamaterialet i personidentifiserbar form etter prosjektslutt, som er beregnet til 31.12.2001. Det blir innhentet samtykke til dette ved bruk av standard taushets- og samtykkeerklæring.

Datafaglig sekretariat finner opplegget for gjennomføringen av prosjektet tilfredsstillende og anbefaler at Datatilsynet gir konsesjon i henhold til rammekonsesjonen for Høgskolen i Vest-Agder.

Datatilsynet

Hilde Lohne Seiler
Høgskolen i Agder
Avdeling for helse- og idrettsfag
Serviceboks 422 KRISTIANSAND

Deres ref	Vår ref (bes oppgitt ved svar)	Dato
	2000/290-2 ofm/-	22.02.2000

KONSESJON TIL Å OPPRETTE PERSONREGISTER IHT RAMMEKONSESJONSORDNINGEN FOR HØGSKOLEN I VEST-AGDER

Datatilsynet har mottatt Deres melding innkommet til oss den 31.01.2000 om opprettelse av personregister i forbindelse med prosjektet "Betydningen av styrketrening for eldre i forhold til de å kunne opprettholde/forbedre ADL-funksjonen".

Vi har gjennomgått materialet og gir Dem med hjemmel i personregisterloven § 9, herved tillatelse til å føre det ovennevnte register, og å innhente opplysninger som er gitt i meldingen.

Som registeransvarlig oppnevnes prosjektleder Hilde Lohne Seiler .

Datatilsynets tillatelse er gitt på følgende vilkår:

- at betingelsene i rammekonsesjonen for Høgskolen i Vest-Agder blir fulgt.
- at første gangs kontakt opprettes gjennom prosjektleder .
- at personidentifiserbare opplysninger ikke registreres ved hjelp av edb. Det elektroniske register kan inneholde et referansenummer som knytter seg til en manuell navneliste. Denne forutsettes oppbevart adskilt fra det elektroniske register og forsvarlig nedlåst i arkivskap.
- at den registeransvarlige setter i verk og holde vedlike nødvendige sikkerhetstiltak slik at personopplysningenes konfidensialitet, integritet og tilgjengelighet til enhver tid er tilstrekkelig; de konkrete krav til informasjonssikkerhet er gitt i Datatilsynets Retningslinjer for informasjonssikkerhet ved behandling av personopplysninger, som er vedlagt.
- at brudd på informasjonssikkerheten som har medført uautorisert utlevering av sensitive personopplysninger, eller ved mistanke om slik utlevering, meldes til

Datatilsynet. Datatilsynet tar forbehold om å gi nye og endrede regler for informasjonssikkerhet når dette finnes nødvendig ut fra personvernhensyn.

- at det innhentes aktivt informert samtykke for alle deler av undersøkelsen. Det forutsettes at samtykket fra respondenten er reelt. Samtykket skal også omfatte en eventuell lagring etter prosjektavslutning i personidentifiserbar form.
- at videobånd oppbevares på forsvarlig måte og nedlåst i arkivskap når de ikke er i bruk.
- at det i informasjonen til respondenten klart kommer fram at undersøkelsen er frivillig, og at vedkommende kan trekke seg fra undersøkelsen på et hvilket som helst tidspunkt.
- at eventuelle merknader fra etisk komite følges opp.
- at det innsamlete materialet slettes/anonymiseres ved prosjektavslutning, senest 31.12.2001.

Dersom prosjektleder ønsker å oppbevare opplysningene i personidentifiserbar form etter prosjektslutt, må arkiveringsspørsmålet først legges frem for Rådet for persondataarkivering i god tid før prosjektavslutning, før spørsmålet igjen forelegges Datatilsynet for avgjørelse.

Med hilsen

Mette Borchgrevink (e f)
rådgiver

Ole F Melleby

Ole Fredrik Melleby
rådgiver

Saksbehandler: Ole Fredrik Melleby, telefon 22 39 69 00

Vedlegg: Taushetserklæring
Retningslinjer for informasjonssikkerhet

Kopi : Datafaglig sekretariat, Bergen

APPENDIX 6:

Questionnaire (Paper I)

Kan1
Kartlegging aktivitet Norge

Hovedskjema

Kjære Kan1 deltaker,

Ved hjelp av besvarelsen fra deg og andre deltakere vil vi få økt kunnskap om det fysiske aktivitetsnivået i den norske befolkning. I tillegg vil vi få bedre forståelse for hvilke forhold som er knyttet til fysisk aktivitet blant voksne og eldre.

Du har selvsagt anledning til å unnlate å svare på enkeltspørsmål. Det er imidlertid viktig at du gir ærlige svar. Informasjonen i dette spørreskjemaet behandles konfidensielt og ditt navn vil verken forekomme i datafiler eller i skriftlig materiale.

Det tar 20-30 minutter å fylle ut spørreskjemaet.
Vennligst følg instruksene underveis.

Skjemaet skal leses ved hjelp av en datamaskin. Bruk sort eller blå penn ved utfylling. Det er viktig at du fyller ut skjemaet riktig:

- Ved avkrysning, sett ett kryss innenfor rammen av boksen ved det svaralternativet som passer best

☒ Riktig

☐X Galt

▨ Om du krysser av i feil boks, retter du ved å fylle boksen slik

- Skriv tydelige **tall** innenfor rammen av boksen

7 | 4 Riktig

| 7 4 Galt

- Bruk **blokkbokstaver** hvis du skal skrive A B C D E F

På forhånd takk for hjelpen!

Bakgrunnsinformasjon

1) Kjønn:
☐ Kvinne
☐ Mann

2) Fødselsår: 19 ☐☐

3) Høyde: ☐☐☐ cm

4) Vekt: ☐☐☐, ☐ kg

5) Hvilken utdanning er den høyeste du har fullført? (Sett ett kryss)

☐ Mindre enn 7 år grunnskole
☐ Grunnskole 7-10 år, framhaldsskole eller folkehøgskole
☐ Realskole, middelskole, yrkesskole, 1-2 årig videregående skole
☐ Artium, økonomisk gymnas, allmennfaglig retning i videregående skole
☐ Høgskole/universitet, mindre enn 4 år
☐ Høgskole/universitet, 4 år eller mer

6) Hva er din hovedaktivitet? (Sett ett kryss)

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

7) Hvor høy var husholdningens samlede bruttoinntekt siste år? (sett ett kryss)
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
☐ Ønsker ikke svare

T T

8) Hvor mange innbyggere er det i din bostedskommune? (sett ett kryss)

☐ Under 1000
☐ 1001 – 5000
☐ 5001 – 10.000
☐ 10.001 – 20.000
☐ 20.001 – 30.000
☐ 30.001 – 100.000
☐ Mer enn 100.000

9) Hvordan vurderer du din egen helse sånn i alminnelighet? (sett ett kryss)

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

10) I hvilken grad begrenser din helse dine hverdagslige gjøremål? (sett ett kryss)

☐ I stor grad ☐ I noen grad ☐ I liten grad ☐ Ikke i det hele tatt

11) Mener du at fysisk aktivitet er viktig for å kunne vedlikeholde egen helse? (sett ett kryss)

☐ Ja, meget viktig for meg
☐ Egentlig tenker jeg ikke så mye på det
☐ Nei, det er ikke så viktig for meg

12) Har du, eller har hatt: (sett gjerne flere kryss)

☐ Astma
☐ Kronisk bronkitt/emfysem/KOLS
☐ Hjerteinfarkt
☐ Angina Pectoris (hjertekrampe)
☐ Hjerneslag/hjerneblødning ("drypp")
☐ Kreft
☐ Spiseforstyrrelser
☐ Annet: ______________________________
☐ Allergi
☐ Psykiske plager du har søkt hjelp for
☐ Sukkersyke (diabetes type I)
☐ Sukkersyke (diabetes type II)
☐ Benskjørhet/osteoporose
☐ Revmatiske lidelser

T T

Fysisk aktivitet

De neste spørsmålene omhandler fysisk aktivitet. Fysisk aktivitet omfatter både:

- fysisk aktivitet i hverdagen (i arbeid, fritid og hjemme, samt hvordan du forflytter deg til og fra arbeid og fritidssysler)
- planlagte aktiviteter (gå på tur, svømming, dansing)
- trening (for å bedre kondisjon, muskelstyrke og andre ferdigheter)

Det er flere nesten like spørsmål - det er meningen

13) Er du *<u>aktivt medlem</u>* av et idrettslag eller en idrettsklubb? (sett ett kryss)

☐ Ja

☐ Nei, men jeg har vært medlem før

☐ Nei, jeg har aldri vært medlem (gå til spm 15)

14) Når ble du medlem for første gang?

Jeg ble medlem da jeg var ☐☐ år gammel

15) Dersom du er fysisk aktiv, hvilke aktiviteter driver du vanligvis med:
(Sett gjerne flere kryss)

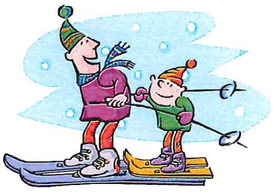
☐ Turgåing
☐ Dans
☐ Golf
☐ Langrenn
☐ Yoga/pilates
☐ Tennis
☐ Ballspill
☐ Stavgang
☐ Svømming
☐ Vanngymnastikk
☐ Alpint/snowboard
☐ Kampsport (karate, judo ol)
☐ Padling/roing
☐ Sykling/spinning
☐ Jogging
☐ Skøyter/bandy/hockey
☐ Trening til musikk i sal
☐ Squash/Badminton/Bordtennis
☐ Treningsstudio (styrketrening, tredemølle, ergometersykkel, elipsemaskin ol)
☐ Annet,

hva:____

T T

16) Hvor ofte trener du på de måtene som er nevnt under?
(Sett ett kryss for hvor ofte du er aktiv på hver måte)

	Aldri	**Sjelden**	**1-3 g/mnd**	**1 dag/uke**	**2-3 dag/uke**	**4-6 dag/uke**	**Daglig**
I idrettslag……………….	☐	☐	☐	☐	☐	☐	☐
På treningssenter………	☐	☐	☐	☐	☐	☐	☐
På jobben eller skolen…	☐	☐	☐	☐	☐	☐	☐
Hjemme………………….	☐	☐	☐	☐	☐	☐	☐
I nærmiljøet……………..	☐	☐	☐	☐	☐	☐	☐
I svømmehall……………	☐	☐	☐	☐	☐	☐	☐
Sykler……………………	☐	☐	☐	☐	☐	☐	☐
Danser……………………	☐	☐	☐	☐	☐	☐	☐
Skitur……………………..	☐	☐	☐	☐	☐	☐	☐
Fottur……………………..	☐	☐	☐	☐	☐	☐	☐



17) Hvor mange timer den siste uken har du vært i fysisk aktivitet i hjemmet eller i tilknytning til hjemmet? Det er kun aktiviteter som varer i minst 10 minutter i strekk som skal rapporteres

	Ingen	**< 1 time**	**1-2 timer**	**3-4 timer**	**> 4 timer**
Lett aktivitet - ikke svett/andpusten………..	☐	☐	☐	☐	☐
Hard aktivitet - svett/andpusten…………….	☐	☐	☐	☐	☐

T T

18) 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 ett kryss i den ruta som passer best)

Lese, ser på fjernsyn eller annen stillesittende beskjeftigelse?............................ ☐

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

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

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

Når du svarer på spørsmålene 19 - 22:

Meget anstrengende – er fysisk aktivitet som får deg til å puste *mye mer* enn vanlig
Middels anstrengende – er fysisk aktivitet som får deg til å puste *litt mer* enn vanlig

Det er kun aktiviteter som varer **minst 10 minutter i strekk** som skal rapporteres

19a) Hvor mange dager i løpet av de siste 7 dager har du drevet med *meget anstrengende* fysiske aktiviteter som tunge løft, gravearbeid, aerobics eller sykle fort? Tenk bare på aktiviteter som varer *minst 10 minutter i strekk*

☐ Dager per uke

☐ Ingen (gå til spørsmål 20a)

19b) På en vanlig dag hvor du utførte *meget anstrengende* fysiske aktiviteter, hvor lang tid brukte du da på dette?

☐☐ Timer ☐☐ Minutter ☐ Vet ikke/husker ikke

20a) Hvor mange dager i løpet av de siste 7 dager har du drevet med *middels anstrengende* fysiske aktiviteter som å bære lette ting, sykle eller jogge i moderat tempo eller mosjonstennis? Ikke ta med gange, det kommer i neste spørsmål.

☐ Dager per uke

☐ Ingen (gå til spørsmål 21a)

20b) På en vanlig dag hvor du utførte *middels anstrengende* fysiske aktiviteter, hvor lang tid brukte du da på dette?

☐ Timer ☐ Minutter ☐ Vet ikke/husker ikke

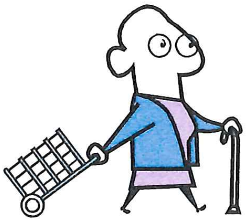
21a) Hvor mange dager i løpet av de siste 7 dager, *gikk du minst 10 minutter* i strekk for å komme deg fra ett sted til et annet? Dette inkluderer gange på jobb og hjemme, gange til buss, eller gange som du gjør på tur eller som trening i fritiden

☐ Dager per uke

☐ Ingen (gå til spørsmål 22)

21b) På en vanlig dag hvor du *gikk* for å komme deg fra et sted til et annet, hvor lang tid brukte du da totalt på å gå?

☐ Timer ☐ Minutter ☐ Vet ikke/husker ikke



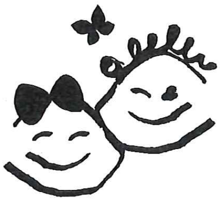
22) Dette spørsmålet omfatter all tid du tilbringer i ro (*sittende*) på jobb, hjemme, på kurs, og på fritiden. Det kan være tiden du sitter ved et arbeidsbord, hos venner, mens du leser eller ligger for å se på TV.

I løpet av de siste 7 dager, hvor land tid brukte du vanligvis totalt på å sitte <u>på en vanlig hverdag</u>?

☐ Timer ☐ Minutter ☐ Vet ikke/husker ikke

23) Nedenfor følger en rekke grunner for å drive med fysisk aktivitet. Vennligst sett ett eller flere kryss for den (de) grunnen(e) som er viktige for deg.

☐ Forebygge helseplager
☐ Holde vekten nede
☐ For å se veltrent ut
☐ Øke prestasjonsevnen
☐ Gjøre fritiden trivelig
☐ For å ha det gøy
☐ Føler jeg må
☐ Komme i bedre form
☐ Anbefalt av lege, fysioterapeut eller liknende
☐ Fysisk og psykisk velvære
☐ For å treffe og omgås andre mennesker
☐ Oppbygging etter sykdom/skade
☐ Oppleve spenning/utfordring
☐ For å få frisk luft



24) Nedenfor følger en rekke grunner for å *ikke* drive med fysisk aktivitet.
Vennligst sett ett eller flere kryss for den (de) grunnen(e) som er viktig(e) for deg.

☐ Har ikke tid
☐ Har ikke råd
☐ Transportproblemer
☐ Negative erfaringer
☐ Bevegelsesproblemer
☐ Tror ikke jeg får det til
☐ Orker ikke
☐ Synes jeg er for gammel
☐ På grunn av min fysiske helse
☐ Har ingen å være fysisk aktiv sammen med
☐ Tidspunktet passer meg ikke
☐ Kjenner ikke til noe tilbud
☐ Engstelig for å gå ut
☐ Mangel på tilbud innen mine interesseområder
☐ Redd for å bli skadet (falle, forstue)
☐ Vil heller bruke tiden min til andre ting
☐ Andre grunner, hva: ______________________________

Transport aktiviteter

De neste spørsmålene handler om dine vaner knyttet til transport og omfatter dine vanlige måter å komme fra et sted til et annet, inkludert hvordan du kommer deg til og fra jobb, butikker, kino, fritidssysler og så videre.

Merk at du skal angi dine transportvaner separat for sommer og vinter.

25a) Hvor mange dager *i en vanlig uke* reiser du med et motorisert transportmiddel som tog, buss, bil eller trikk?

Om sommeren	**Om vinteren**
☐☐ Dager per uke	☐☐ Dager per uke

25b) På *en vanlig dag* hvor du reiser med motorisert transportmiddel, hvor lang tid bruker du da totalt i transportmiddelet?

Om sommeren	**Om vinteren**
☐☐ Timer ☐☐ Minutter	☐☐ Timer ☐☐ Minutter

26a) Hvor mange dager i *en vanlig uke* sykler du *minst 10 minutter i strekk* for å komme fra et sted til ett annet?

Om sommeren	**Om vinteren**
☐ Dager per uke	☐ Dager per uke

26b) På *en vanlig dag* hvor du *sykler* for å komme deg fra et sted til ett annet, hvor lang tid bruker du da totalt på å sykle?

Om sommeren	**Om vinteren**
☐☐ Timer ☐☐ Minutter	☐☐ Timer ☐☐ Minutter

T T

27a) Hvor mange dager i *en vanlig uke* går du *minst 10 minutter i strekk* for å komme fra et sted til ett annet?

Om sommeren	**Om vinteren**
☐ Dager per uke	☐ Dager per uke

27b) På *en vanlig dag* hvor du går for å komme deg fra et sted til ett annet, hvor lang tid bruker du da totalt på *å gå*?

Om sommeren	**Om vinteren**
☐ Timer ☐ Minutter	☐ Timer ☐ Minutter

28) Dersom du er yrkesaktiv, hvordan kommer du deg vanligvis til og fra arbeid?

- ☐ Bil/motorsykkel
- ☐ Sykkel
- ☐ Ikke aktuelt
- ☐ Offentlig transport (tog, buss, og liknende)
- ☐ Til fots

TV, PC og søvnvaner

De neste spørsmålene handler om dine vaner knyttet til bruk av **TV og PC utenom jobb.** I tillegg vil vi kartlegge dine søvnvaner

29) Utenom jobb: Hvor mange timer ser du vanligvis på TV og sitter med PC på en hverdag? (Sett ett kryss)

- ☐ Mindre enn 1 time
- ☐ 1 - 2 timer
- ☐ 2 - 3 timer
- ☐ 3 - 4 timer
- ☐ 4 - 5 timer
- ☐ Mer enn 5 timer

30) Utenom jobb: Hvor mange timer ser du vanligvis på TV og sitter med PC på en helgedag? (Sett ett kryss)

- ☐ Mindre enn 1 time
- ☐ 1 - 2 timer
- ☐ 2 - 3 timer
- ☐ 3 - 4 timer
- ☐ 4 - 5 timer
- ☐ Mer enn 5 timer

T T

31) Hvor mange timer i døgnet sover du vanligvis på en hverdag?
(Sett ett kryss)

☐ Mindre enn 3 timer
☐ 3 - 5 timer
☐ 5 - 8 timer
☐ 8 - 10 timer
☐ 10 timer eller mer

32) Hvor mange timer i døgnet sover du vanligvis på en helgedag eller fridag?
(Sett ett kryss)

☐ Mindre enn 3 timer
☐ 3 - 5 timer
☐ 5 - 8 timer
☐ 8 - 10 timer
☐ 10 timer eller mer

Kosthold, røyk og alkohol

I denne delen av spørreskjemaet er det fokus på kosthold og dine røyke- og alkoholvaner. Vi er klar over at kostholdet varierer fra dag til dag. Prøv derfor så godt du klarer å ta ett gjennomsnitt av dine spisevaner og ha det siste året i tankene når du svarer.

33) Har du røykt/røyker du daglig? (sett ett kryss)

☐ Ja, nå
☐ Ja, tidligere
☐ Aldri (Gå videre til spørsmål 36)

34) Hvis du har røykt daglig tidligere, hvor lenge siden er det du sluttet?

☐ år

35) 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?

☐ Alder i år

Hvor mange år til sammen har du røykt daglig?

☐ Antall år

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36) Bruker du snus? (sett ett kryss)

☐ Ja, daglig ☐ Av og til ☐ Aldri

37) Hvor ofte drikker du alkohol? (Sett ett kryss som stemmer best med dine vaner)

☐ Aldri
☐ Månedlig eller sjeldnere
☐ 2 - 4 ganger pr måned
☐ 2 - 3 ganger per uke
☐ 4 ganger i uken eller oftere

38) Når du drikker alkohol, hvor mange "drinker" tar du vanligvis?
En "drink" tilsvarer en ½ liter pils, ett glass vin, ett drammeglass
(Dersom du ikke drikker alkohol skal du ikke krysse)

☐ 1 - 2 ☐ 3 - 4 ☐ 5 - 6 ☐ 7 - 8 ☐ 9 eller mer

39) Hvor mange enheter med frukt og grønnsaker spiser du i gjennomsnitt hver dag?
(Med enhet menes for eksempel 1 frukt, 1 glass juice, 2-3 poteter, 1 skål bær, 1 porsjon grønnsaker, 1 porsjon salat)

☐☐ Antall porsjoner frukt
☐☐ Antall porsjoner grønnsaker

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

	Aldri/ Sjelden	**1 g/uke**	**2 g/uke**	**3 g/uke**	**4 g/uke**	**5 g/uke**	**6 g/uke**	**Hver dag**
Frokost…….	☐	☐	☐	☐	☐	☐	☐	☐
Lunsj……….	☐	☐	☐	☐	☐	☐	☐	☐
Middag…….	☐	☐	☐	☐	☐	☐	☐	☐
Kveldsmat…	☐	☐	☐	☐	☐	☐	☐	☐

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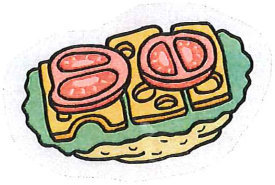
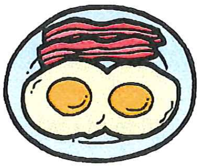
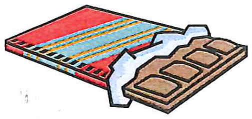
41) **Hvor ofte spiser du vanligvis disse matvarene?**
(Sett ett kryss per linje)

	0-1 g/mnd	**2-3 g/mnd**	**1-3 g/uke**	**4-6 g/uke**	**1-2 g/dag**
Poteter (kokte, stekte, potetmos)........................	☐	☐	☐	☐	☐
Pasta/ris..	☐	☐	☐	☐	☐
Kjøtt (reint kjøtt av storfe, lam, svin, vilt)..................	☐	☐	☐	☐	☐
Kvernet kjøtt (pølser, hamburger, kjøttdeig, kjøttkaker)	☐	☐	☐	☐	☐
Kylling..	☐	☐	☐	☐	☐
Grønnsaker (ikke poteter)................................	☐	☐	☐	☐	☐
Frukt og bær...	☐	☐	☐	☐	☐
Mager fisk (torsk, sei, ol)................................	☐	☐	☐	☐	☐
Fet fisk (laks, ørret, makrell, sild, kveite, uer, ol).........	☐	☐	☐	☐	☐
Grovt brød...	☐	☐	☐	☐	☐
Salt snacks (potetgull, saltstenger, ol).................	☐	☐	☐	☐	☐
Godteri/sjokolade.......................................	☐	☐	☐	☐	☐
Kaker/kjeks..	☐	☐	☐	☐	☐







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42) Hvor mye drikker du vanligvis av følgende? (Sett ett kryss for hver linje)

	Sjelden/ aldri	**1-3 glass pr mnd**	**1-3 glass pr uke**	**4-6 glass pr uke**	**1-3 glass pr dag**	**4-6 glass pr dag**	**>7 glass pr dag**
Helmelk…………	☐	☐	☐	☐	☐	☐	☐
Lettmelk…………	☐	☐	☐	☐	☐	☐	☐
Ekstra lett melk…	☐	☐	☐	☐	☐	☐	☐
Skummet melk…	☐	☐	☐	☐	☐	☐	☐
Juice………………	☐	☐	☐	☐	☐	☐	☐
Vann………………	☐	☐	☐	☐	☐	☐	☐
Brus med sukker…	☐	☐	☐	☐	☐	☐	☐
Brus uten sukker…	☐	☐	☐	☐	☐	☐	☐
Kaffe………………	☐	☐	☐	☐	☐	☐	☐
Te…………………	☐	☐	☐	☐	☐	☐	☐
Pils………………	☐	☐	☐	☐	☐	☐	☐
Vin…………………	☐	☐	☐	☐	☐	☐	☐
Brennevin…………	☐	☐	☐	☐	☐	☐	☐

Holdninger til fysisk aktivitet

I denne siste delen er det fokus på dine holdninger til fysisk aktivitet. Du nærmer deg slutten av skjemaet. **Hold ut** ☺

43) Tenk deg alle former for fysisk aktivitet. Ta stilling til påstanden: *Jeg er sikker på at jeg kan gjennomføre planlagt fysisk aktivitet selv om*:

	Ikke i det hele tatt 1	**2**	**3**	**4**	**5**	**Veldig sikker 6**	**7**
Jeg er trett…………………………………	☐	☐	☐	☐	☐	☐	☐
Jeg føler meg nedtrykt……………………	☐	☐	☐	☐	☐	☐	☐
Jeg er bekymret……………………………	☐	☐	☐	☐	☐	☐	☐
Jeg er sint på grunn av noe……………	☐	☐	☐	☐	☐	☐	☐
Jeg føler meg stresset…………………	☐	☐	☐	☐	☐	☐	☐

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44) Tenk på alle former for fysisk aktivitet. For hver påstand, angi i hvilken grad du er enig/uenig. (Sett ett kryss for hver påstand)

	Helt enig 1	2	3	4	5	6	Helt uenig 7
Om jeg er regelmessig fysisk aktiv eller ikke er helt opp til meg	☐	☐	☐	☐	☐	☐	☐
Hvis jeg ville, hadde jeg ikke hatt noen problemer med å være regelmessig fysisk aktiv	☐	☐	☐	☐	☐	☐	☐
Jeg ville likt å være regelmessig aktiv, men jeg vet ikke riktig om jeg kan få det til	☐	☐	☐	☐	☐	☐	☐
Jeg har full kontroll over å være regelmessig fysisk aktiv	☐	☐	☐	☐	☐	☐	☐
Å være regelmessig fysisk aktiv er vanskelig for meg	☐	☐	☐	☐	☐	☐	☐

45) I hvilken grad beskriver disse påstandene deg som person? (Sett ett kryss for hver påstand)

	Passer dårlig 1	2	3	4	Passer bra 5
Jeg ser på meg selv som en person som er opptatt av fysisk aktivitet	☐	☐	☐	☐	☐
Jeg tenker på meg selv som en person som er opptatt av å holde seg i god fysisk form	☐	☐	☐	☐	☐
Å være fysisk aktiv er en viktig del av hvem jeg er	☐	☐	☐	☐	☐

46) Har familien din (medlemmer i husstanden): (Sett ett kryss for hver påstand)

	Aldri	Sjelden	Noen få ganger	Ofte	Veldig ofte	Passer ikke
Oppmuntret deg til å være fysisk aktiv	☐	☐	☐	☐	☐	☐
Diskutert fysisk aktivitet sammen med deg	☐	☐	☐	☐	☐	☐
Forandret planene sine slik at dere kunne drive fysisk aktivitet sammen	☐	☐	☐	☐	☐	☐
Overtatt oppgaver for deg, slik at du fikk mer tid til å være fysisk aktiv	☐	☐	☐	☐	☐	☐
Sagt at fysisk aktivitet vil være bra for helsen din	☐	☐	☐	☐	☐	☐
Snakket om hvor godt de liker å være fysisk aktive	☐	☐	☐	☐	☐	☐

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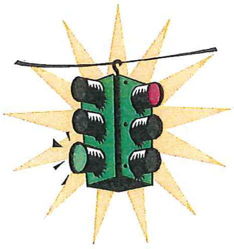
47) Har vennene dine/bekjente/familiemedlemmer utenfor husstanden:
(Sett ett kryss for hver påstand)

	Aldri	Sjelden	Noen få ganger	Ofte	Veldig ofte	Passer ikke
Foreslått at dere skulle drive fysisk aktivitet sammen..	☐	☐	☐	☐	☐	☐
Oppmuntret deg til å være fysisk aktiv............	☐	☐	☐	☐	☐	☐
Gitt deg hjelpsomme påminnelser om fysisk aktivitet som: "Skal du mosjonere i kveld?".....	☐	☐	☐	☐	☐	☐
Forandret planene sine slik at dere kunne drive fysisk aktivitet sammen.........................	☐	☐	☐	☐	☐	☐
Sagt at fysisk aktivitet vil være bra for helsen din..	☐	☐	☐	☐	☐	☐
Snakket om hvor godt de liker å være fysisk aktive..	☐	☐	☐	☐	☐	☐

48) Er det i ditt nærmiljø:
(Sett ett kryss for hver påstand)

	Helt uenig	Litt uenig	Litt enig	Helt enig
Trygge steder å gå (park/friområde, turvei, fortau) som er tilstrekkelig opplyst..	☐	☐	☐	☐
Mange steder der du kan være fysisk aktiv (utendørs, svømmehall etc.)...	☐	☐	☐	☐
Flere tilrettelagte tilbud om trening og fysisk aktivitet (som kunne være aktuelle for deg)..	☐	☐	☐	☐
Greit å gå til butikker (10-15 min å gå, fortau langs de fleste veiene)..............................	☐	☐	☐	☐
Lett tilgang til gang- eller sykkelveier...	☐	☐	☐	☐
Så mye trafikk i gatene at det er vanskelig eller lite hyggelig å gå......	☐	☐	☐	☐
Fotgjengeroverganger og lyssignal som gjør det enklere å krysse veien..	☐	☐	☐	☐



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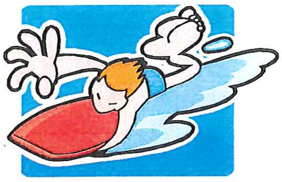
49) Omtrent hvor lang tid vil det ta deg å gå hjemmefra til:
(Sett ett kryss for hver linje)

	1-5 min	6-10 min	11-20 min	21-30 min	> 30 min	Vet ikke
Butikk for dagligvarer……………………	☐	☐	☐	☐	☐	☐
Et friområde/park/turvei………………	☐	☐	☐	☐	☐	☐
Helsestudio/treningssenter/svømmehall/idrettshall/utendørs idrettsanlegg	☐	☐	☐	☐	☐	☐
Skog/mark/fjell…………………………	☐	☐	☐	☐	☐	☐

50) I hvilken utstrekning mener du at daglig fysisk aktivitet kan ha gunstig effekt for å forebygge følgende sykdommer: (Sett ett kryss for hver linje)

	Stor effekt	Liten effekt	Ingen effekt	Vet ikke
Hjerte- og karsykdom……………………	☐	☐	☐	☐
Muskel- og skjelettlidelser……………	☐	☐	☐	☐
Diabetes type 2…………………………	☐	☐	☐	☐
Kreft…………………………………………	☐	☐	☐	☐
Høyt blodtrykk…………………………	☐	☐	☐	☐
Psykiske lidelser………………………	☐	☐	☐	☐
Overvekt og fedme……………………	☐	☐	☐	☐
Mage-/tarmsykdommer…………………	☐	☐	☐	☐
Astma og allergi………………………	☐	☐	☐	☐
KOLS……………………………………………	☐	☐	☐	☐



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Etter at du har fylt ut spørreskjemaet og gått med aktivitetsmåleren i 7 dager, legger du skjemaet og aktivitetsmåleren i den vedlagte konvolutten og returnerer den til oss.

Tusen takk for hjelpen

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Kan1

kartlegging **aktivitet** Norge 2008