Dizziness and Benign Paroxysmal Positional Vertigo among older adults

– health-related quality of life and associated factors

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Cover illustration by Linda Pålemo

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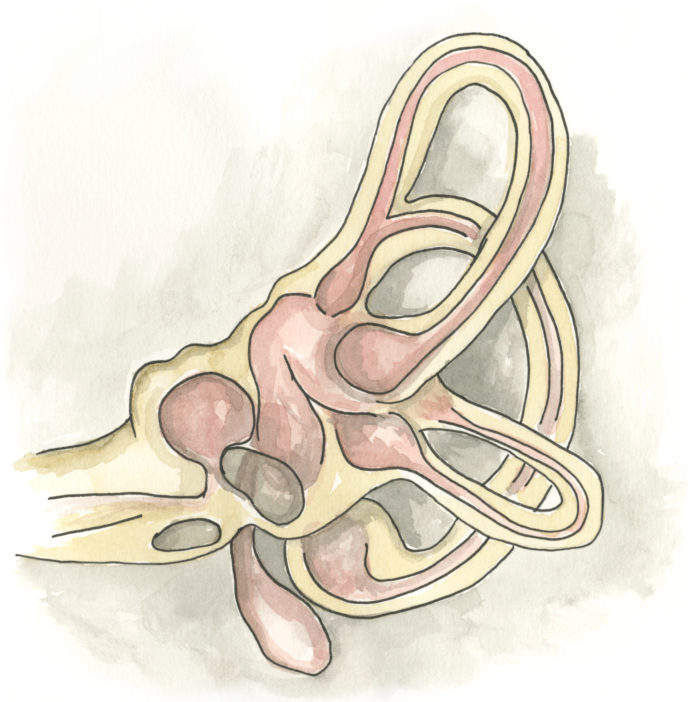
Brand factory

Inte ens

Inte ens en grå liten fågel
Som sjunger på grönan kvist
Det finns på andra sidan
och det tycker jag nog blir trist

Inte ens en grå liten fågel
och aldrig en björk som står vit
Men den skönaste dagen
som sommaren ger
har det hänt att jag längtat dit.

Nils Ferlin



“The vestibular system”, illustration by Linda Pålemo. The inner ear is comprised of the cochlea and the vestibular system, together responsible for sound detection and balance. The vestibular system provides us with information about head motion and position. The organ consists of three semicircular canals and two otolith organs.

Abstract

Dizziness is a common complaint reported by more than 30% of persons over 70 years of age and accounts for 2% of all visits in healthcare annually. Benign paroxysmal positional vertigo (BPPV) is a common and treatable cause of dizziness. The overall aim of this thesis was to enhance knowledge of dizziness, BPPV and associated factors among older adults. The secondary aim was to focus on BPPV diagnosis.

Method
In paper I, patients admitted to the Ear-Nose-Throat clinic at Södra Älvsborg Hospital due to dizziness or vertigo were asked questions about dizziness and were investigated for BPPV with Dix-Hallpike and log roll test.
Papers II-IV include material from the Gothenburg H70 birth cohort studies, which is a multidisciplinary longitudinal cross-sectional cohort survey. The participants were investigated at age 75 (paper II) for symptoms of dizziness, signs of BPPV using side-lying test, walking speed, self-rated health and health-related quality of life (HRQL) measured using Short Form-36 (SF-36). In papers III and IV the participants were investigated at age 79 for dizziness, history of falls, walking speed, comorbidity and intake of medication. Fear of falling was measured using the questionnaire Falls Efficacy Scale (FES (S)) (paper III). HRQL was measured using SF-36, dependence on activities of daily life (ADL) measured by the Katz index and Sense of Coherence (SOC) using SOC-13 (paper IV).

Results
Results from paper I demonstrated that answering "yes" to having dizziness when lying down or turning over in bed increased the likelihood of having BPPV by an odds ratio of 60. Results from papers II – IV showed that HRQL, number of falls, self-rated health and walking speed were negatively associated with having dizziness at both 75 and 79 years of age. There were no big differences regarding HRQL, self-rated health, tiredness, falls or walking speed between persons with BPPV compared to those having general

dizziness/impaired balance. Dizziness at age 79 was reported by over half of the participants with no gender differences. Dizziness was related to a higher risk of falls among women - an association not seen among men. Dizzy individuals had a stronger fear of falling, a higher number of medications and more comorbidity than those without dizziness. Enhanced number of medications increased the risk of falling. Sense of coherence (SOC) did not differ between dizzy and non-dizzy persons.

Conclusion
Dizziness and BPPV are common among older adults and are negatively associated with HRQL and self-rated health. Since BPPV is a cause of dizziness that is potentially curable, it is important to liberally test for, and treat, the condition in order to improve HRQL and well-being. Older adults with dizziness had higher comorbidity, walked slower and tended to fall more often than older adults without dizziness.

Keywords
Dizziness, vertigo, unsteadiness, falls, older adults, walking speed, health-related quality of life, sense of coherence

Sammanfattning på Svenska

Bakgrund

Yrsel bland äldre är vanligt och cirka 30 % av personer över 70 år beräknas lida av yrsel och obalans. Godartad lägesyrsel (BPPV), även kallat kristallsjuka, är den vanligaste enskilda orsaken till yrsel från innerörats balansorgan. BPPV beror på att kristaller (otoliter) lossnar från innerörats membran och hamnar i båggångarna. Symptomen är yrsel som kommer vid lägesändring, t ex när man lägger sig eller vänder sig i sängen, eller lutar huvudet bakåt. Många upplever även ostadighetskänsla när man står och går. BPPV är vanligare i högre åldrar och vanligare bland kvinnor. Diagnosen BPPV ställs med hjälp av Dix-Hallpikes test och sidolägestest. Vid ställd diagnos är BPPV oftast lätt att behandla och bota. Att ha yrsel är en av de största riskfaktorerna för att ramla och rädsla för att ramla är obehagligt och skrämmande. Långvarig yrsel har förknippats med nedsatt livskvalitet och ökad sjuklighet. Gånghastighet är ett pålitligt mått att skatta hälsa på och långsam gånghastighet kan ses som en riskfaktor för sjuklighet. Gånghastighet <1m/s räknas som en stark riskmarkör för fall, ohälsa och ökad mortalitet.

Syfte

Avhandlingens övergripande syfte är att på olika sätt öka kunskapen om yrsel och framförallt BPPV med fokus på yrsel och ostadighet hos äldre. Avhandlingen syftar även till att belysa yrsel i relation till hälsorelaterad livskvalitet (HRQL) och känsla av sammanhang (KASAM).

Metod

Delstudie I är genomförd på Södra Älvsborgs sjukhus i Borås. Studien inkluderade patienter som remitterats till öron-näs-halskliniken pga yrsel. Patienterna undersöktes för BPPV och fick frågor om yrsel. Delstudie II-IV inkluderade material från Gothenburg H70 birth cohort studies, en multidisciplinär longitudinell kohortstudie där personer valts ut baserat på födelsedag i månaden. Deltagarna undersöktes i delstudie II vid 75 års ålder avseende yrsel, BPPV, HRQL (SF-36), gånghastighet och hälsa. I delstudier III och IV undersöktes deltagarna vid 79 års ålder för yrsel, falltendens, gånghastighet, fallrädsla, mediciner och sjukdomar (III) samt HRQL (SF-36), känsla av sammanhang (SOC-13) och självskattad hälsa (IV).

Resultat

Delstudie I visade att yrsel, när man vänder sig eller lägger sig i sängen, är mycket vanligt bland patienter med BPPV. Multivariat regressionsanalys visade att sannolikheten för BPPV ökade med en oddskvot på 60 om patienten upplevde yrsel när de la sig eller vände sig sängen.
Delstudie II visade att yrsel/ostadighet eller BPPV var associerat med nedsatt gånghastighet, ökad trötthet och lägre självskattad hälsa jämfört med de som inte uppgav någon yrsel.
Delstudier III och IV visade att yrsel var lika vanligt förekommande bland kvinnor som män vid 79 års ålder och 40% av deltagarna hade ramlat senaste året. Kvinnor, men inte män, med yrsel hade ramlat i högre utsträckning jämfört med de utan yrsel. Personer med yrsel gick långsammare än de utan yrsel samt hade fler mediciner och fler sjukdomar. Ett ökat antal mediciner var också förenat med ökat antal rapporterade fall. Att ha yrsel var associerat med lägre HRQL och självskattad hälsa bland både män och kvinnor, men påverkade inte graden av känsla av sammanhang.

Konklusioner av avhandlingsarbetet

Yrsel i sängen är starkt förknippat med godartad lägesyrsel. Att fråga patienter som söker för yrsel om de blir yra när de vänder sig eller lägger sig i sängen kan vara ett bra sätt att identifiera patienter med godartad lägesyrsel och därmed förenkla diagnostiken.

Yrsel, oavsett orsak, är förknippat med sämre HRQL. Personer med yrsel och godartad lägesyrsel är mer trötta, känner sig mindre friska och går långsammare än de utan yrsel. Det är därför viktigt att tidigt diagnostisera och behandla godartad lägesyrsel.

Kvinnor som är yra faller i högre utsträckning än män. Yra personer går långsammare, har fler sjukdomar och tar fler mediciner än de som inte har yrsel. Att ha många mediciner var associerat med fall och antal mediciner skulle kunna användas för att identifiera personer med ökad risk för fall.

Hälsorelaterad livskvalitet, självskattad hälsa och trötthet var sämre hos äldre med yrsel än hos äldre utan yrsel. Att ha yrsel inverkade inte på graden av känsla av sammanhang.

List of papers

This thesis is based on the following studies, referred to in the text by their Roman numerals (I-IV).

I. **Ellen Lindell**, Caterina Finizia, Mia Johansson, Therese Karlsson, Jerker Nilson, Måns Magnusson

Asking about dizziness when turning in bed predicts examination findings for benign paroxysmal positional vertigo.

J vest research, 28 (2018) 339-347

II. **Ellen Lindell**, Lena Kollén, Mia Johansson, Therese Karlsson, Lina Rydén, Hanna Falk Erhag, Hanna Wetterberg, Anna Zettergren, Ingmar Skoog*, Caterina Finizia*

Dizziness and benign paroxysmal positional vertigo and health-related quality of life among older adults in a population-based setting.

Manuscript submitted

III. **Ellen Lindell**, Lena Kollén, Mia Johansson, Therese Karlsson, Lina Rydén, Anna Zettergren, Kerstin Frändin, Ingmar Skoog*, Caterina Finizia*

Dizziness and its association with walking speed and falls efficacy among older men and women in an urban population.

Aging clin exp res. 2019 sep 5

IV. **Ellen Lindell**, Lena Kollén, Mia Johansson, Therese Karlsson, Lina Rydén, Madeleine Mellqvist Fässberg, Hanna Falk Erhag, Ingmar Skoog*, Caterina Finizia*

Health-related quality of life and sense of coherence among dizzy older adults in an urban population.

Manuscript submitted

*Contributed equally

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Abbreviations

ADL	Activities of Daily Living
BPPV	Benign Paroxysmal Positional Vertigo
CI	Confidence Interval
COR	Cervico-Ocular Reflex
CRM	Canalith Reposition Manoeuvre
FoF	Fear of Falling
IADL	Instrumental Activities of Daily Living
OR	Odds Ratio
pBPPV	posterior canal Benign Paroxysmal Positional Vertigo
hBPPV	horizontal canal Benign Paroxysmal Positional Vertigo
HRQL	Health-Related Quality of Life
PRO	Patient Reported Outcome
SD	Standard Deviation
SOC	Sense Of Coherence
SRH	Self-Rated Health
VOR	Vestibular-Ocular Reflex
WHO	World Health Organization
QoL	Quality of Life

1. Introduction

1.1 Balance

The word balance can mean many things. In a clinical setting it is often associated with function and being able to stand in an upright position. The ability to stand upright in a bipedal standing is essential for gait, locomotion and functioning in everyday life. We develop the ability to stand in an upright position during the first years of childhood. For postural control, we use input from vision, the vestibular system, somatosensory input from the skin, muscles and joints as well as cognitive function, *figure 1* [1]. The sensory systems act together in synergistic effects. One system cannot necessarily provide all information for maintaining balance. Vision alone cannot provide information whether it is self-motion or motion of the surroundings occurring without the vestibular system aiding with input regarding velocity [2]. Proprioception provides information about the body´s position and its relation to the surface, especially through the soles of the feet, in order to help maintain posture [3, 4]. With increasing age, all input from somatosensory systems tends to decrease including that from the vestibular system and older adults may therefore rely on visual input to a higher extent [5].

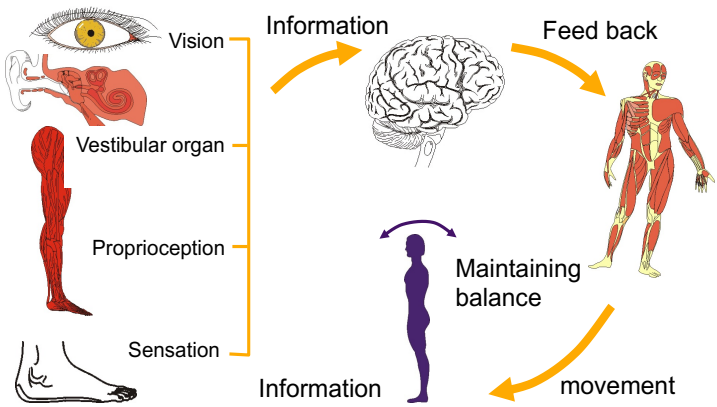

Figure 1. Maintaining balance, by Måns Magnusson, Lund, reproduced with permission from the illustrator.

1.1.1. Postural control

Postural control is a set of complex motor skills derived from multiple sensorimotor processes that help us maintain balance of the body and to make appropriate musculoskeletal responses to avoid falling. Maintaining *postural orientation* and *postural equilibrium* are the two main goals of postural control [6]. The former refers to control over body alignment and the latter to coordinating strategies to stabilize the body's center core mass [6, 7]. Important biomechanical tools to maintain balance and stability are the lower extremities. Impaired function of the feet or legs may affect balance, including for instance hip or knee surgery [1, 8]. Persons with vestibular deficits are often dependent on vision to maintain balance and decrease sway, especially on uneven ground or in darkness [5, 9]. Sensory systems may overlap to replace each other in cases of incapacity. Vestibular deficits acquired in adulthood may have greater functional impact and require training for compensation [10].

1.1.2. Vestibular system

The vestibular system is part of the inner ear, which is mainly responsible for detection of sound and balance. The inner ear is comprised of the cochlea and the vestibular system, responsible for sound detection and balance respectively. The latter provides us with information about head motion and position. The organ consists of three semicircular canals (posterior, horizontal and anterior canal) as well as two otolith organs; the utricle and the saccule, *figure 2*. The semicircular canals report rotational acceleration whereas the otolith organ reports linear acceleration and gravitation. The semicircular canals are filled with endolymph, a viscous fluid moving with the head. Angular movements are reported through velocity of the endolymph inside the canals. The movements are registered by the ampullary cupula, the sensory organ, and report the head movement in the planes where the canals are oriented. The vestibular system is integrated with the visual and somatosensory systems and provides us with information about vertical orientation and three-dimensional space as well as a global perception of up, down, left and right [11]

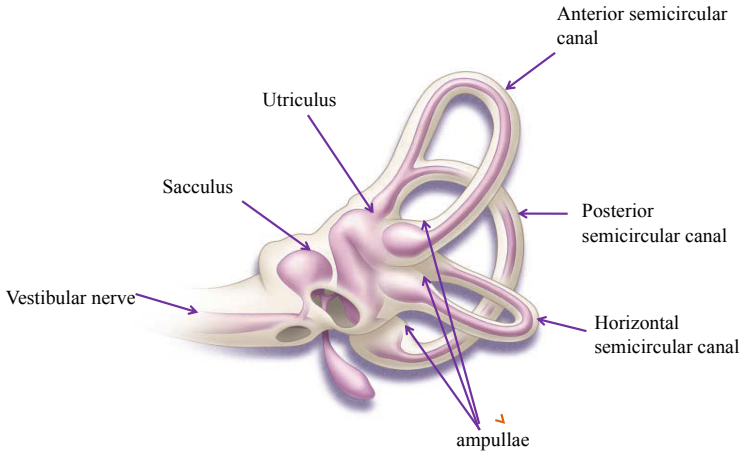

Figure 2. The inner ear with the cochlea and the vestibular organ comprising the three semicircular canals and the otolith organ: saccule and utricle. Reprinted from CMAJ 30 September 2003; 169(7), Page(s) 681-693 by permission of the publisher. © 2003 Canadian Medical Association

Due to the vestibulo-ocular reflex (VOR), where activation of the vestibular system causes eye-movement, the examination of the dizzy patient is mainly performed by investigating eye movement – both voluntary and involuntary movement (nystagmus). Videonystagmography is used to detect nystagmus with higher certainty as well as to avoid visual fixation that may suppress nystagmus, *figure 3.* A cervical cause of dizziness may also be observed, although the mechanism is not fully proven, with a link between the cervical muscles and joints of the neck and the vestibular nuclei called the cervico-ocular reflex (COR) [12].

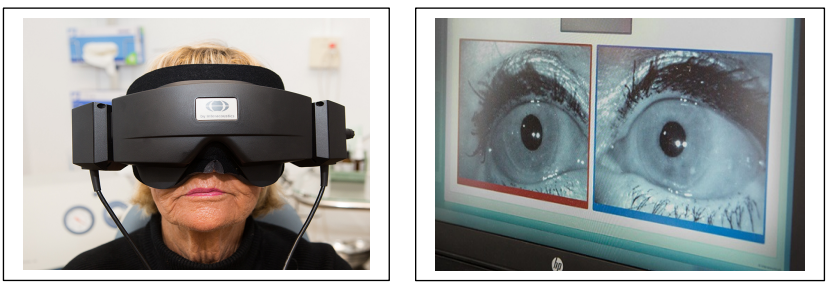

Figure 3. Investigation with videonystagmography, Södra Älvsborgs Hospital. Photo: Pernilla Lundgren.

“The Ear”, illustration by Linda Pålemo. The vestibular system is part of the inner ear, which is responsible for detection of sound and balance.

1.2 Dizziness

The terms dizziness and vertigo cover a wide range of symptoms. Dizziness not only refers to loss of balance but also includes disorders of spatial orientation, motion perception, unsteadiness or vertigo as an illusion of rotatory motion. Dizziness is a frequent reason for seeking medical care and approximately 2% of all admissions to health care is due to dizziness [13, 14]. Having problems with dizziness is more often seen among women [15, 16]. Despite the fact that impaired balance and dizziness are such frequent complaints, especially in higher ages, we know relatively little about the mechanisms causing dizziness and outcomes from vestibular testing does not always correlate with the burden of patient reported symptoms of dizziness [17, 18].

1.2.1 Dizziness among older adults

Dizziness is a very common complaint in the older patient [14] and in individuals over 70 years of age, prevalence of dizziness is in excess of 30% and increases with higher ages [15, 16]. Dizziness in higher ages may have multiple causes and is most often part of a decline in function of many balance enhancing systems, also referred to as multisensory dizziness [19, 20]. With age, a decline in vestibular end organ occurs [21] and older adults with vestibular causes of dizziness may have fewer rotatory symptoms and more non-specific symptoms of dizziness causing instability and unsteadiness of gait [20, 22]. Dizziness in high ages has been suggested to be part of natural ageing and part of a geriatric syndrome, which is a multifactorial condition caused by a decrease in the functioning of several system as well as higher comorbidity [20, 23, 24]. Kao et al identified factors predisposing to dizziness that included depressive symptoms, cataracts, abnormal balance or gait, postural hypotension, diabetes, previous myocardial infarction and the use of three or more medications [23].

An important aspect of investigating dizziness in higher ages is distinguishing between to what extent impairment of balance is caused by the ageing process and when it represents a pathophysiological process. For the vestibular system, aging is associated with the degeneration of otoconia, hair cells and a reduction of cells in the vestibular nuclei [21]. Among both patients and medical staff, dizziness may be considered to

be part of aging and therefore not treatable. The most important reason for dizziness that can be treated is BPPV, why testing for BPPV is always important. Among older adults, non-vestibular as well as vestibular causes of dizziness are common. Among elderly, multisensory deficits and multifactorial aetiologies are more frequently seen than among younger individuals [25]. Psychological factors as a primary cause of dizziness is probably less frequent as is vestibular migraine in higher ages, although isolated vestibular migraine without headache is common in postmenopausal women with a lifetime prevalence estimated around 1% [25, 26].

Older adults tend to have several different medications for treatment of chronic diseases and polypharmacy is common as the number of medications has increased during the last decade [27]. Older people are frailer and more sensitive to adverse drug reactions. Older adults also consume more drugs than younger age groups and are therefore also more exposed to drug-drug interactions. Many medications have side effects that may cause dizziness. Several lists exist regarding inappropriate drug-use for older people like the Beers criteria [28] and The Laroche list [29]. The Swedish National Board of Health and Welfare has developed a list of medications that should be avoided in elderly populations. These include drugs with anticholinergic effects, long-acting benzodiazepines, tramadol and codeine. Other medications associated with dizziness are: antiepileptic drugs, antidepressants, anxiolytics, sedatives, muscle relaxants and strong analgesics [25]. It is of importance to reduce unnecessary and inappropriate drug use when meeting older patients.

One way to reduce dizziness and tendency to fall can be to lessen the number of drugs that impact on balance, according to the list from the Swedish National Board of Health and Welfare when possible. Other ways include trying to reduce orthostatic hypotension [30] and improve visual acuity through treating cataract or optimizing glasses [31]. Older adults with impaired balance have a higher risk of falling. Reducing the risk of falls in older individuals with dizziness is therefore important when possible.

1.2.2 Benign paroxysmal positional vertigo

Benign paroxysmal positional vertigo (BPPV) is the single most common cause of dizziness originating from the inner ear [32] and is characterized by repeated episodes of dizziness triggered by positional changes. BPPV is common and accounts for many healthcare visits annually. The life-time prevalence of BPPV is estimated to be around 2.4% [33] but symptoms of BPPV are found to be very common among older adults and can even be found unrecognized [34-36]. BPPV increases with increasing age and is said to peak in the sixth decade of life [33]. The frequency of BPPV in the community varies between surveys, *table 1*. BPPV more often affects women in a ratio of 3:2 and the right ear is more often affected than the left [37-40].

Table 1. Surveys of reported BPPV

Year	First Author	Age	Study design	Method	n	n tested	n with BPPV	% with BPPV
1988	Mizukosh [41]	All ages	Retrospective	Code for BPPV	1342	1342	204	10.3-17.3/ 100 000
2000	Oghalai [34]	50-95	Cross-Sectional	Dix-Hallpike	100	100	9	9%
2005	Ekvall-Hansson [14]	65+	Cross-Sectional	Dix-Hallpike	197	38	15	8%
2007	Von Brevern [33]	28-82	Retrospective	Telephone interview	4077	1003	53	1-year prevalence BPPV 1.6%
2012	Kollén [35]	75	Cross-Sectional	Side-lying	667	571	63	11%
2015	Van der Zaag-Loonen [36]	70+	Cross-Sectional	Question-naire, Dix-Hallpike	989	45	14	1.4%
2019	Lindell [42]	70-85	Cross-Sectional	Question-naire, Dix-Hallpike	324	22	6	1.9%
2019	Hülse [40]	All ages	Retrospective	ICD-10 code BPPV	70 000 000		322164	0.46%

Articles of epidemiological research on BPPV.

1.2.2.1 BPPV pathology

BPPV is caused by displaced free-floating otoconia (or canaliths), which are small crystals of calcium carbonate. The crystals are normally attached to the otolithic membrane in the utricle, but may detach from the utricle and enter the semi-circular canal, where it may stimulate the sensitive cupula to send false signals of movement to the brain, resulting in dizziness [32]. All three canals may be affected but the posterior canal BPPV (pBPPV) is by the far most commonly affected canal (80-90%) due to gravitational forces, followed by the horizontal canal (hBPPV) [32]. Anterior canal BPPV is rare and accounts only for 1-5% of all cases [43]. The majority of cases of BPPV are idiopathic and most probably occur through degeneration of the otolithic membranes [39]. Other causes include head trauma and inner ear disorders, such as vestibular neuritis or Meniere's disease as well as sudden sensorineural hearing loss [32, 39].

There are two types of BPPV:

- *canalolithiasis*: where the debris is freely floating in the semicircular canals
- *cupulolitiasis*: where the debris is adherent to the cupula itself

An association between BPPV and impaired calcium metabolism as well as low vitamin-D levels exists [44, 45]. Nevertheless, in the light of current knowledge, supplementation with vitamin-D is only considered a treatment option in individuals with recurrent BPPV [45].

1.2.2.2 Symptoms of BPPV

The typical symptom of BPPV is dizziness provoked by positional changes of the head in respect to gravity. Patients typically report symptoms of dizziness or vertigo when laying down or turning in bed, when tilting the head backwards or when bending forward [46]. The symptom is a short, spinning sensation (rotational vertigo) often accompanied by nausea and sometimes even vomiting. The spinning sensation usually lasts less than a minute if the head is held still, yet returns with new head movements. Many patients report experiencing their first symptoms in the morning when turning over in bed and asking about dizziness when turning in bed can be a good way to identify persons having BPPV [33,

42]. A majority of patients with BPPV report interruption of daily activities and sick leave at work due to the condition [33].

The diagnosis of BPPV is made through diagnostic tests; the Dix-Hallpikes test *figure 4*, for pBPPV and supine roll-test for hBPPV [47]. Another option for diagnosing pBPPV is the side lying test [48] which may be easier to perform among older patients with back pain. The Dix-Hallpike test is however the most commonly used test for diagnosing BPPV of the posterior canal and is considered gold standard for condition diagnosis. The sensitivity and specificity of the test is 79-82% and 71-75% respectively [49]. BPPV is most often treatable and a delay in treatment of BPPV will increase the cost for society and also has a negative impact on the patients' quality of life.

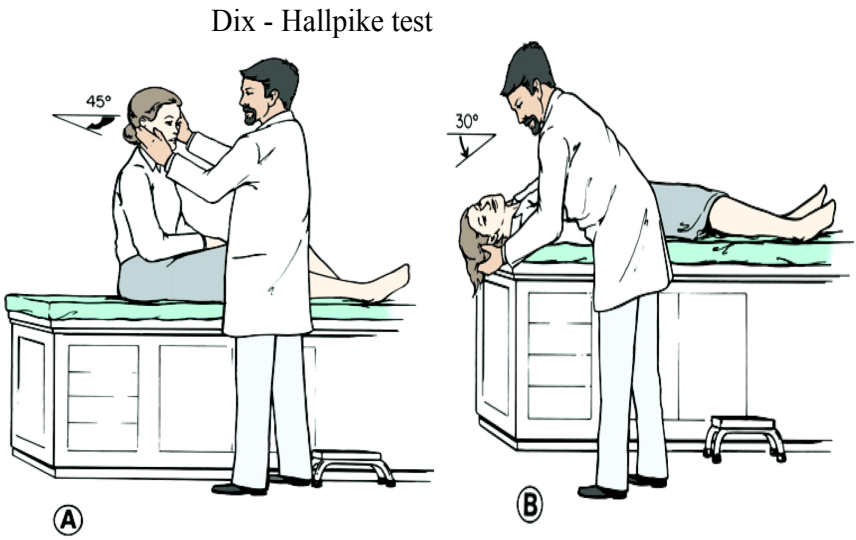

Figure 4, Dix-Hallpike test. Reprinted from CMAJ 30 September 2003; 169(7), Page(s) 681-693 by permission of the publisher. © 2003 Canadian Medical Association

A person with a typical history of BPPV, i.e. with vertigo during testing but without any detectable nystagmus, might still have BPPV and is often termed to have subjective BPPV or probable BPPV according to the Barany society [47, 50]. Reasons for not having positional nystagmus

during the tests may be due to lack of use of Frenzel's goggles making visual fixation possible, which thereby suppresses nystagmus. Other explanations may include only small amounts of calcium carbonate otoconia, where the otoconia may be enough to produce nausea or dizziness, but not enough to induce nystagmus [51].

According to the Barany society, the diagnostic criteria of pBPPV are:

1. *Recurrent attacks of positional vertigo or positional dizziness, provoked by lying down or turning over in the supine position*.
2. *Duration of attacks < 1 min*.
3. *Positional nystagmus elicited after a latency of one or few seconds by the Dix-Hallpike test or side-lying test. The nystagmus is a combination of torsional and vertical nystagmus*.
4. *Not attributable to another disorder*.

1.2.2.3 Treatment of BPPV

BPPV is one of few disorders of dizziness that often can be easily treated. Treatment is made through canalith reposition manoeuvres (CRM), a manoeuvre that aims to move the displaced otoconia back to the utricle, thereby stopping the false signals and the vertigo symptoms. Through a series of head position changes, the CRM moves the otoliths from the canal back to the utricle. Once the crystals are back in the utricle, they no longer cause symptoms.

The most used and recommended manoeuvres for treating BPPV are the Epley's or Semont's manoeuvre for pBPPV, *figure 5*, and Gufonis or barbeque manoeuvre for hBPPV [52, 53]. Strong recommendations exist for treating BPPV once it is identified [53] and treating patients for pBPPV is safe and effective [52]. Older adults may need repeated treatment before total remission of the condition occurs [54].

There is no consensus on when BPPV is to be considered cured. Recovery may be defined as absence of nystagmus during testing with the Dix-Hallpike manoeuvre, which is the most frequently used definition. However, even after treatment with repositioning manoeuvres, a sensation of dizziness may remain for a while. The absence of nystagmus (but presence of dizziness) may be due to otoconial particles remaining in the

semicircular canal, not enough to produce positional nystagmus but still enough to produce mild symptoms, which is the most supported theory. Also, patients with typical symptoms of dizziness for BPPV but no detectable nystagmus may benefit from CRM [55, 56]. Recurrence of BPPV after a symptom-free period is high (35-50%) regardless of treatment choice [52, 57].

1.2.2.4 BPPV among older adults

BPPV is the most common cause of vertigo found in dizziness clinics, accounting for up to 25-40% of all cases [58]. BPPV among older adults may be milder, causing a sensation of unsteadiness rather than the spinning sensation often seen in younger adults [22, 59]. Because of milder positional symptoms, older people seem to adapt to the condition and BPPV may therefore be undetected until tested for [34-36]. However, the condition may still create a sensation of unsteadiness and could increase the risk of falling [60]. BPPV is common in older individuals and may have an impact on HRQL and impairment of daily activities. Although affecting quality of life, many older adults tend to wait longer before seeking medical care in addition to needing more manoeuvres in order to achieve recovery [59, 61].

1.2.3 Evidence for rehabilitation of dizziness

Treatment of BPPV is safe, without side effects and is highly recommended to minimize dizziness and enhance well-being [47, 52, 53], *table 2, figure 5*. There is also evidence that treating unilateral vestibular hypofunction with vestibular rehabilitation improves subjective symptoms of dizziness and may even improve balance [10, 62]. There is evidence that training, like balance and strengthening exercises, improves balance among older people. However, the belief that general physical activity, such as walking or bicycling should improve balance, is only supported by weak evidence [63]. Nonetheless, exercise and fall-preventing intervention is safe and may help to prevent falls among older adults and should be liberally recommended [64, 65]. Many older adults are afraid of falling and therefore reduce their physical activity due to fear. Despite this, the evidence for exercise interventions to reduce fear of falling (FoF) is scarce among older adults in the community [66].

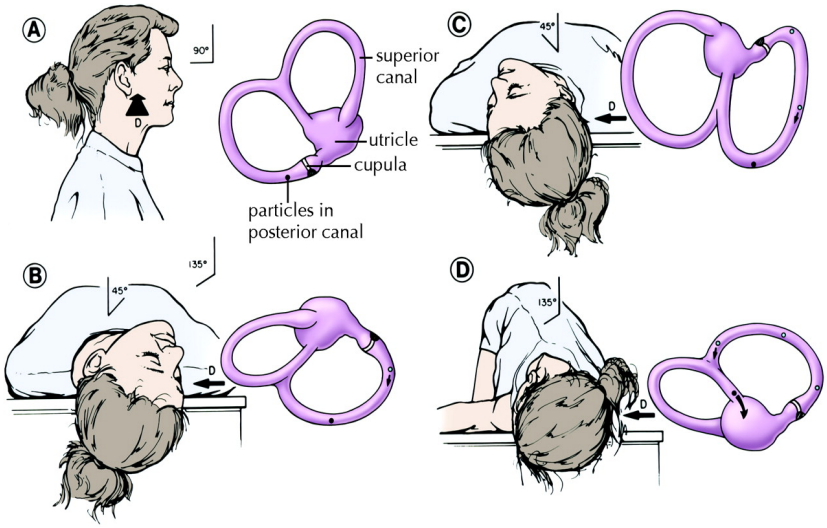

Figure 5, Epley's manoeuvre for treatment for treatment of pBPPV. Reprinted from, CMAJ 30 September 2003; 169(7), Page(s) 681-693 by permission of the publisher. © 2003 Canadian Medical Association"

Vestibular rehabilitation is known to be helpful for patients with vestibular disorders of all ages [10]. Jung et al found that vestibular rehabilitation therapy reduced dizziness even in patients with unspecific dizziness when evaluating 240 patients older than 70 years [67]. Weight training together with a high protein diet is important in order to avoid sarcopenia and muscle loss [68]. Muscular strength is important in fall avoidance and the American Geriatric Society's guidelines suggest that balance exercises including gait and strength training are of particular benefit to older adults at risk for falling [69].

Table 2. Effectiveness of treatment of pBPPV with canalith repositioning manoeuvres				
Year	**Author**	**No. patients**	**Treatment options**	**Result, cure rate***
2004	Salvinelli [70]	156	Semont Calcium antagonist No treatment	94% 56% 35%
2012	Amor-Dorado [71]	40 41	Epley Brandt-Daroff	80% 25%
2012	Chen [72]	65 63	Semont sham	85% 14%
2012	Mandala [73]	174 168	Semont sham	87% 0%
2014	Hilton [52] (Cochrane review)	11 trials, 745 participants	Epley	OR 9.62, 95% CI 6.0-15.4; for treatment comparted to sham. **
2018	Guerra-Jiménez [74]	264	Epley	67%
2018	Cetin [75]	25 25	Epley Brandt-Daroff	76% 64%
2019	Nahm [61]	143	Epley	66% (geriatric setting)

**Cure rate defined as no detectable nystagmus during testing with Dix-Hallpike. ** 8 studies, 507 participants for curable*

1.3 Health-related quality of life

Even if the concept of quality of life has been known since ancient Greece, there is no strict definition of quality of life (QoL). Quality of life may be explained by the differences between the hopes and expectations of the individual and the individual's present experience [76]. Already in 1946 the World Health Organization (WHO) defined health as "A complete physical, mental, social well-being and not merely the absence of disease" [77] indicating that health is a multidimensional concept including quality of life.

In medicine and health care, the term Health-Related Quality of Life (HRQL) is often used and measured using patient-reported symptoms of health and well-being. HRQL can be seen as a multidimensional construct, also referred to as self-perceived health or to the functional abilities of a person [78]. HRQL encompasses a person's subjective experience that relates both directly and indirectly to health, disease and

“Joy and quality of life”, illustration by Linda Pålemo. Already in 1946 the World Health Organization (WHO) defined health as “A complete physical, mental, social well-being and not merely the absence of disease”

disability. Assessments of HRQL are often used to evaluate different treatments and for comparisons between groups, to evaluate treatment and cost-effectiveness in specific treatments (eg cancer) as well as in larger non-randomized cohorts when controlling for various factors [79].

1.3.1 Dizziness and HRQL

Ability to walk, stand and move safely is essential for living independently. Walking ability and postural control can therefore predict morbidity and HRQL [80-82]. Walking ability and balance are not purely motor tasks, but are representative of more complex, sensorimotor behaviors as well as cognitive and affective aspects [83, 84]. Dizziness has previously been reported to correlate with depression and reduced HRQL [85]. Having vestibular disorders has been shown to be negatively related to HRQL [85] and may reflect the negative impact dizziness may have on everyday life. Having dizziness or impaired balance is associated with a functional impairment, highlighting why assessment instruments that measure functional aspects, such as the Dizziness Handicap inventory (DHI) or Short Form-36 (SF-36), often yield a reduction in HRQL as a result of dizziness. [85, 86]. Patients with BPPV report improved HRQL after treatment with CRM [70, 86, 87] and treatment of the condition is therefore strongly recommended [53].

1.4 Self-rated health

Self-rated health or self-reported health, is a widely used (and more poorly understood) measurement. It is based on asking patients or individuals to evaluate their health on a four- or five-point scale alternatively to compare their health status with others of their age. Self-reported health status can be obtained by asking a single question: “In general, compared to others of your age, how would you rate your health? Response options often include the following: “excellent”, “very good”, “good”, “fair” or “poor”. Self-rated health is one of the most frequently used health indicators in research. The measure may not only be seen as an indicator of health but a “summary statement about the way in which numerous aspects of health, both subjective and objective, are combined

” Fall”, illustration by Linda Pålemo. The WHO defines a fall as “an event which results in a person coming to rest inadvertently on the ground, floor or other lower levels”. As many as 32-42% of persons over 70 experience at least one fall every year.

within the perceptual framework of the individual respondent" [88], an "all-inclusive" question targeting several aspects of health.

Self-reported health status is a strong predictor of morbidity, health care utilization and hospitalization [89, 90]. Poor self-rated health has even been shown to be a better indicator for hospitalization and mortality than assessment of health indicators performed by medically trained staff [91]. The question regarding self-rated health is widely used in the United States and individuals rating their health as "excellent" compared to "poor" had lower insurance expenditures [89]. In Sweden, 77% of the adult population rate their health as good [92]. Differences in self-rated health is seen with socioeconomic status where highest self-rated health is found among the strongest socioeconomic groups [92].

1.5 Falls

Worldwide, falls are a major health problem estimated to cause nearly 650 000 deaths each year globally. The WHO defines a fall as *"an event which results in a person coming to rest inadvertently on the ground, floor or other lower levels"[93]*. Age is the most important risk factor for falling and the tendency to fall increases with age and frailty level [94]. As many as 32-42% of persons over 70 experience at least one fall every year [93]. Women are more prone to falling and seek medical care compared to men, albeit men tend to die from falls to a higher extent [95]. Reasons for these differences may be found in the theory that men have a higher risk-taking behaviour.

The most frequent reason for falling is loss of balance due to stumbling, whereas the second most common reason is dizziness or impaired balance [96]. Dizziness, poor balance and inability to move among older individuals may increase risk of falling [81, 97]. Approximately 270 000 persons are annually admitted to hospitals due to fall-related accidents in Sweden, of which approximately 2% (n=1700) die each year as a result of a fall-related accident [94]. The majority of the deaths are persons over 80 years of age [94]. Falls and fall-related injuries cost large amounts annually. Vestibular impairment with dizziness and BPPV often affects balance and may contribute to falls [34, 96, 98].

“Walking”, illustration by Linda Pålemo. Walking speed is a valuable tool for evaluating health and a walking speed <1m/s is considered a risk of poorer health and morbidity.

Risk factors for falls among older adults can be divided into intrinsic (related to the body; diseases, morbidity), extrinsic (environmental) or behavioural [97]. Intrinsic factors associated with falls are multiple morbidity, orthostatic hypotension, impaired vision and balance disturbance. Extrinsic factors could be time of the day (tiredness in the afternoon), slippery floor, unfavourable footwear etc. Behavioural risk factors may be risk taking behaviour, hurrying, transferring techniques (moving from one to another place, eg falls from wheelchair or bed) [97]. Inability to adapt to quick changes as well as stride length have been associated with recurrent falls [99, 100]. Among older individuals, a high incidence of falls is correlated with comorbidity and frailty, such as a decrease in muscle strength or sarcopenia as well as slowed protective reflexes where even relatively mild falls may become dangerous [97, 101]. Exercise and balance training programs may help to reduce rate of falls [65], but the evidence that exercise reduces dizziness and improves balance, in general, is weaker [63].

1.6 Walking speed

Walking speed is a valuable tool when evaluating health. In fact, normal gait speed may represent one of the most suitable tests to evaluate physical performance and health [102, 103] and is considered a highly valid and reliable test [104]. A normal gait function provides a valuable illustration of general well-being and multi-systemic function [104, 105]. Low walking speed, on the other hand, may predict morbidity and hospitalization and is also associated with mortality and poorer health [102, 105, 106]. Walking speed is fairly constant through adulthood and declines with advancing age. The average walking speed among 70-year-olds is 1,10-1,25 m/s and a walking speed <1m/s is considered a risk of poorer health and morbidity even among adults not reporting problems with activity of daily living (ADL) or mobility [102, 107]. Hospitalization has been shown to be associated with a decrease in gait speed and mobility [108]. Low speed of gait and low physical activity level are associated with frailty [109].

1.7 Fear of falling

The connection between anxiety, fear of losing balance and dizziness is well established [110]. Increased anxiety levels are very common during acute stages of vertigo. Levels of anxiety normally decrease during habituation, albeit the anxiety may persist in some cases. The link between vestibular dysfunction and panic disorders is known as is the connection between the limbic and vestibular system, although not fully understood [111]. Fear of falling (FoF) is often reported among older adults, especially if having experienced a fall. FoF is a feeling related to the risk of falling during one or more activities of daily living and may lead to activity restriction and avoidance, even among non-fallers, thus affecting HRQL [112-114]. Activity restriction may also lead to lower limb deficiency and weakness, seen more often among persons with dizziness [16].

Although FoF and fall-related self-efficacy are used interchangeably, the two constructs should be seen as different concepts albeit related. While self-efficacy is the belief in one´s own ability to successfully accomplish something [115], FoF, according to Tinetti, can be defined as a lasting concern about falling that leads to avoidance of activities that a person is otherwise capable of performing [116]. FoF can be a normal adaptive response to challenging environments or situations, which might prevent people from engaging in risk activities, but FoF may also be irrational or phobic, which can result in activity avoidance and physical restriction. Bandura defined self-efficacy as one´s belief in the own ability to succeed in specific situations or to accomplish a task. Self-efficacy plays a major role in how to approach a goal, a task or a challenge.

"Self-belief does not necessarily ensure success, but self-disbelief assuredly spawns failure"

Albert Bandura

Many older adults are afraid of falling and have low fall-related self-efficacy, especially if they have experienced a fall causing them harm. Fear of falling can have a serious impact on an older person's health and HRQL as it often reduces their physical and social activities [114]. Many exercise and balance enhancing programs have been tested and evaluated.

However, the evidence for reducing FoF using balance enhancement and muscle strength training, is scarce, and tends only to reduce FoF short term. The evidence of exercise for reducing fear of falling is inadequate when examining the long-term perspective [66].

1.8 Sense of coherence

Sense of coherence (SOC), originally introduced by Aaron Antonovsky (1923-1994) refers to the ability to identify and utilize internal and external recourses to cope with stressors and maintain health [117]. Antonovsky was interested in how good health is preserved and called the concept *salutogenesis*, compared to pathogenesis, focusing on disease [118]. In the salutogenetic concept, health is defined as a continuum between the two poles of wellness and disease, where a person´s sense of coherence influences his or her position on the continuum [119]. His book, "Health, Stress and Coping", was released in 1979 in which he presents theories of the Salutogenetic Model of Health. The concept of SOC is defined as: The extent to which one "has a pervasive, enduring though dynamic feeling of confidence that (1) the stimuli deriving from one's internal and external environments in the course of living are structured, predictable, and explicable; (2) the resources are available to one to meet the demands posed by these stimuli; and (3) these demands are challenges, worthy of investment and engagement" [120]. Antonovsky found that different persons cope with stress in various ways and developed the theory of generalized resistance resources (GRRs) [118, 121]. The GRRs reflect a person´s resources and capacity to cope with life and are both genetic and of psychosocial and constitutional character [119]. Antonovsky also introduced three components of SOC namely: *Comprehensibility* - the extent to which one perceives events as making sense, *Manageability* - the extent to which one feels he or she can cope and *Meaningfulness* - the extent to which one feels that life makes sense and that challenges are worthy of commitment. Having a high sense of coherence has been shown to reduce mortality and promote health [122-124].

SOC reflects health and HRQL mainly in terms of the mental and psychosocial aspects [119, 125]. It tends to increase through life and is often higher in the second half of life [126, 127] and also tends to be high even in advanced ages, at least if controlling for diseases and cognitive deficits. Being of male sex is sometimes associated with higher SOC [127].

1.9 Activities of daily living

Activities of daily living (ADL) refers to people´s daily basic self-care activities. Dependence of ADL is often used in health care as a measure of a person's functional status, particularly among elderly with disabilities. Common ADLs refers to basic functions of living and include eating, bathing, dressing. The ADL index was first presented by Katz [128]. The index has thereafter been expanded to not only include activities necessary for fundamental functioning, but also to the individual's ability to live independently in the community. These activities include cleaning, moving around, preparing meals, shopping, communication etc and are called instrumental activities of daily living (IADL).

2. Aims

The overall aim of this thesis was to enhance knowledge of dizziness, BPPV and associated factors, especially among older adults. Additional aims included focusing on identification and diagnosing BPPV.

Aim of papers:

Paper I. To assess useful questions when suspecting dizziness caused by benign paroxysmal positional vertigo (BPPV) as well as identifying if a single question can be useful in order to identify or distinguish patients with BPPV from other dizziness aetiology.

Paper II. To investigate and compare 75-year-olds with dizziness caused by BPPV to those with symptoms of general dizziness/impaired balance, and to those reporting no dizziness, in terms of HRQL, dizziness-symptoms, falls, tiredness and walking speed in a population-based setting.

Paper III. To investigate presence of dizziness and its association with falls, walking speed and fear of falling, including sex differences among 79-year-olds in a population-based setting. Secondary aims included describing the relationship between dizziness, falls, number of medications and diseases.

Paper IV. To investigate HRQL and Sense of Coherence, self-rated health and tiredness in relation to dizziness, among 79-year-olds in a population-based setting.

3. Patients and Methods

Table 3. Study design papers I-IV					
Study	**Design**	**Participants**	**Age**	**n** Women/Men	**Outcome**
I	Cross-sectional	Dizzy patients referred to ENT-clinic	26-88	149 (96/53)	Study specific questionnaire Test for BPPV
II	Cross-sectional, longitudinal	75-year-olds, population-based H70	75	841 (512/329)	Occurrence of dizziness Test for BPPV Walking speed Falls SF-36 (HRQL)
III		79-year-olds, population-based H70	79	662 (404/258)	Occurrence of dizziness Sex differences Walking speed Falls FES (S) medication comorbidity
IV					Occurrence of dizziness ADL and IADL SF-36 (HRQL) SOC-13 SRH

Abbreviation: BPPV= benign paroxysmal positional vertigo, HRQL = Health-related quality of life, SF-36= Short form health survey 36, FES (S)= Falls Efficacy Scale Swedish version, SOC-13= Sense of coherence 13, SRH= self-rated health

3.1 Study design

3.1.1 Study design paper 1

A prospective cross-sectional study that included 149 patients referred due to dizziness to the ENT clinic Södra Älvsborgs Hospital during 2013 and 2014. Inclusion criteria were seeking medical care due to dizziness or imbalance, being over 18 and having no neurological signs. A total of 160 patients were eligible for the study and 149 agreed to participate. The patients were investigated by a doctor or by a trained nurse. Patients were first asked questions according to a study specific questionnaire, *table 7* and thereafter investigated with Dix-Hallpike test and supine roll test for BPPV.

3.1.2 Study design papers II-1V

Paper II

A total of 1295 persons were invited to participate at age 75 and a total of 841 persons agreed to participate in the multidisciplinary study. Of these, 673 (398 women and 275 men) answered the questions regarding dizziness. The study was conducted in 2005.

Papers III+IV

A total of 1063 men and women all aged 79, were invited for participation, of which 662 individuals (404 women and 258 men) agreed to participate. Of these, 647 (395 women and 252 men) answered the questions regarding dizziness. The study was conducted in 2009-2010.

Gothenburg H70 birth cohort studies

Papers II-IV are part of the longitudinal study Gothenburg H70 birth cohort studies. Participants were living in the Gothenburg area and selected and invited per mail depending on date of birth in the month, using the

Swedish national population register, *table 4,* [129]. The invited participants included both persons living in institutions and in private households, *table 5*. The persons invited were all born in 1930 and invited for participation in the longitudinal study at age 70, 75, 79 and 85 years. In this thesis, results from investigations at age 75 and 79 are presented. The participants were first invited by a letter with study information and a consent form and then contacted by telephone with an inquiry of participation. If no answer, up to three reminders were sent.

The participants were investigated during a one-day general examination by a research nurse or physician, as well as a physiotherapist, at the neuropsychiatric outpatient clinic at Sahlgrenska University Hospital in Gothenburg or in the participant's home. Additional examinations were performed, like brain imaging and DEXA-scanning, at other institutions and locations but are not included as a part of this thesis. The participants took part in a general health interview, including questions about dizziness, falls, self-rated health, diseases and disorders. Self-rating questionnaires were filled out during the one-day examination or at home and then sent back.

Table 4. Gothenburg H70 birth cohort study born in 1930, investigated in 2005 and 2009

	2005			**2009**		
	Women	**Men**	**Total**	**Women**	**Men**	**Total**
Eligible sample	819	549	1368	733	460	1193
Could not be traced	7	10	17	18	16	34
Unable to communicate in Swedish language	17	7	24	26	14	40
Deceased	4	11	15	28	26	54
Technical reason and emigrated	8	9	17	2	0	2
Effective sample	**783**	**512**	**1295**	**659**	**404**	**1063**
Refused to participate	271	183	454	255	146	401
Total	**512**	**329**	**841**	**404**	**258**	**662**
Response rate	65%	64%	65%	61%	64%	62%

Table 5. Gothenburg H70 birth cohort study, sample characteristics						
	2005			2009		
	Women	Men	Total	Women	Men	Total
	n (%)			n (%)		
Marital status:	451	296	747	389	256	645
Single	27 (6)	25 (8)	52 (7)	31 (8)	27 (11)	58 (9)
Married	196 (43)	217 (64)	413 (55)	131 (34)	174 (68)	305 (47)
Divorced	79 (18)	30 (9)	109 (15)	58 (15)	18 (7)	76 (12)
Widower	149 (33)	24 (7)	173 (23)	169 (43)	37 (14)	206 (32)
Education:	466	319	785	-	-	-
Primary education ≤ 9 y	260 (56)	164 (51)	424 (54)	-	-	-
Primary education > 9 y	153 (33)	85 (27)	238 (30)	-	-	-
University degree	53 (11)	70 (22)	123 (16)	-	-	-
Housing:	446	310	756	388	253	641
Apartment	307 (69)	197 (64)	504 (68)	263 (68)	149 (59)	412 (64)
Privat house	138 (31)	113 (36)	251 (34)	111 (29)	100 (40)	211 (33)
Sheltered living	1 (0)	-	1 (0)	14 (4)	4 (2)	18 (3)

Asking about educational level was not included in the questionnaire at age 79. y=years

3.2 Outcome measures

3.2.1 Test for BPPV

In paper I, the participants were evaluated for BPPV at the Ear-Nose-Throat department at Södra Älvsborgs Hospital. The patients were investigated by a trained nurse or by a doctor. The Dix-Hallpike or supine roll test was used when investigating for BPPV. In the Dix-Hallpike test, the patient is seated and the head turned 45 degrees to the side being tested. The patient is then laid back quickly into a supine position with the tested ear down, *figure 4*. The test was considered positive and the diagnoses of pBPPV was made if the Dix-Hallpike test provoked vertigo and a torsional up-beating nystagmus (canal-specific nystagmus) was seen. The vertigo and nystagmus should only last for seconds. Horizontal canal BPPV was diagnosed with the supine roll test. The test was performed

with the patient lying on their back with the face upwards. The head was then quickly rotated 90 degrees to one side. The eyes were observed for horizontal nystagmus beating down to the floor (geotropic nystagmus) or up to the ceiling (apogeotropic nystagmus). In paper II, the participants were evaluated for BPPV using the side-lying test instead of the Dix-Hallpike test. In the side lying test, the participants head was turned, with the nose pointing 45° away from the tested ear. Then, with the head in this position, the person was moved from a seated position to be lying on the side and observed for nystagmus and occurrence of dizziness. The participant was then returned to sitting position [48]. A person was categorized as having probable BPPV if experiencing dizziness and/or having nystagmus during the test.

3.2.2 Walking speed

Walking speed is considered a highly valid and reliable test and is a valuable indicator for health and level of fitness [104]. A normal walking speed reflects good health and appropriate functional status as well as an overall well-being [104, 106]. High walking speed has been associated with survival among older adults [106].

Walking speed was tested across a distance of 20 m at self-selected and maximum speed, with no acceleration or deceleration phase in papers II and III.

3.2.3 Falls

In papers II and III, participants were asked if they had fallen using the questions: ”Have you fallen during the last year? (yes/no)”, “How many times have you fallen?” and in paper III the participants were additionally asked: “If you have fallen, did you get any injury? (no/fracture/soft tissue damage/other)”.

3.2.4 Comorbidity

The participants were asked through a list of conditions and diseases and were asked to list their medications.

3.3 Patient reported outcome measures

Patient reported outcome measures (PROM) or self-rating questionnaires are tools used to measure information about the patient's, or person's, views of their health status. PROMs are often standardized and validated questionnaires that allow intervention and measure a patient's perceptions of their general health or their health in relation to a specific disease or symptom. PROMs can be either generic, like measuring HRQL (SF-36, KASAM) or symptom specific (FES (S)).

Self-rating questionnaires were used in all papers; HRQL, FES (S), SOC-13 and ADL-index, *table 6*. The participants were asked the questions in paper I and in papers II-IV they filled out the self-rating questionnaire independently.

Table 6. Patient reported outcome questionnaires used in Paper I-IV

Questionnaire	Paper I	Paper II	Paper III	Paper IV
Study specific	x			
SF-36		x		x
FES (S)			x	
SOC-13				x
ADL/IADL				x

Abbreviation: SF-36= Short Form-36, FES (S)= Falls Efficacy Scale Swedish version, SOC-13= Sense of coherence-13, ADL/IADL= activities of daily living / instrumental activities of daily living

3.3.1 Study specific questions paper I-IV

In aiding the diagnosis of dizziness and vertigo, only few validated questionnaires exist. In paper I, the patients were asked questions using a study specific questionnaire, *table 7*. In paper II, the question ''Do you have any problems with dizziness or impaired balance?' (seldom/ sometimes/ frequently) was used to identify persons with dizziness. Additional questions included, "Do you experience unsteadiness when walking?" (seldom/ sometimes/ frequently), "Do you have problems with vertigo/dizziness when turning in bed or bending backwards/forwards?" (seldom/ sometimes/ frequently).

Concerning health and tiredness; the questions “Do you feel healthy?” (yes/no) and “Do you feel generally tired?” (yes/no) were asked.
In papers III and IV, the question ‘‘Do you have any problems with dizziness, unsteadiness or impaired balance?’’(yes/no) was used in order to discriminate between participants with or without dizziness.

Table 7. Study specific questionnaire paper I

Question	**Response options**
Do you get dizzy when laying down or turning over in bed?	Yes/No
If so, which side is worse?	Left/Right/Both/Neither
Do you get dizzy when sitting up?	Yes/No
Do you get dizzy when standing up?	Yes/No
Preferred head-laying side during sleeping?	Left/Right/Both/Neither
For how long does the dizziness last?	Seconds/Minutes/ Hours/ Continuous
Can you get dizzy without positional change?	Yes/No
Are you unsteady by gait?	Yes/No
Have you experienced previous head trauma?	Yes/No
Recent prolonged bed rest?	Yes/No
Previous ear disease?	Yes/No
Previous similar symptoms?	Yes/No
Do you have neck problems?	Yes/No
Do you have double vision?	Yes/No
New hearing impairment?	Yes/No

3.3.2 Short Form-36

One of the most widely used instruments for measuring quality of life is the generic scale Short Form 36 (SF-36) [130]. The instrument is designed to measure HRQL in diverse medical groups and consists of 36 questions distributed over eight subscales: physical function (PF), role limitation due to physical problems (RP), bodily pain (BP), general health (GH), vitality (VT), social function (SF), role limitation due to

emotional problems (RE) and mental health (MH) [130], appendix 1. Every component is standardized and the scores for each domain range from 0 to 100 where low scores represent a low HRQL. The SF-36 measures self-perceived physical and mental health status. Validity and reliability have been evaluated and confirmed in prior studies [131]. The instrument is translated into Swedish and has been validated in a representative sample of the population [132].

3.3.3 Falls Efficacy Scale

Balance confidence in task performance without falling was measured using the Falls Efficacy Scale Swedish version (FES (S)) [133], *appendix 2.* The questionnaire includes 13 items targeting activities of everyday life. The answers are given on a visual analog 0–10-point scale, where 0 = not confident at all and 10 = completely confident. The questionnaire consists of three parts: the first six questions measure balance confidence during personal activities of daily living (ADLs), question number seven measures confidence while walking up and down stairs and questions eight to thirteen measure balance confidence during instrumental activities of daily life (iADLs). A higher score (maximum of 130 points) indicates better confidence in performing the different activities without falling. The test-retest reliability of the Swedish version of the scale was found to be acceptable by Hellström et al [133].

3.3.4 Sense of coherence-13

The sense of coherence (SOC) instrument was originally developed by Antonovsky as a 29-item questionnaire [120]. In paper IV, the shorter 13-item version (SOC-13) was used, *appendix 3*. The questionnaire is designed to cover three domains; comprehensibility, manageability and meaningfulness. Each question is scored on a 7-point scale were the score ranges from 1-7. The total score of the SOC-13 questionnaire ranges from 13 to 91. The higher the score, the stronger the sense of coherence. The validity of the questionnaire is reported to be acceptable and test-retest stable [134].

3.3.5 Self-rated health

Self-rated health (SRH) is one of the most frequently used self-assessed indicators of health, where individuals are asked to evaluate their global health status on a four- or five-point scale [135, 136]. Self-rated health in paper IV was measured using the question: ”How is your general health?” with response options ranging from “very good”, “good”, “poor” to “very poor”. In addition, respondents also answered whether they felt well or generally tired, (yes/no).

3.3.6 ADL and IADL dependence

The Katz Index of independence in Activities of Daily Living is an instrument used to assess functional status and ability to perform activities of daily living (ADL) independently. The original Index consists of six questions regarding function of bathing, dressing, toileting, transferring, continence and feeding [137]. The index has been expanded with an additional scale for instrumental activities of daily living (IADL) such as housework, shopping and cleaning [138]. The questions are scored yes or no for independence in each of the functions. The participants in paper IV were asked for ADL and IADL dependence, *appendix 4*.

3.4 Statistical analyses

Descriptive statistics were provided as means with a standard deviation of the mean. The significance level was reported for two-tailed tests and the significance level used was 5 % for all papers.

Paper I
For comparison between two groups, Fisher’s exact test was used for dichotomous variables and Mann Whitney U-test for continuous variables. In order to find variables indicative of having a BPPV diagnosis, uni- and multivariable logistic regression analyses were performed. The result was presented as an odds ratio with 95% CI, corresponding p-value and area under receiver operating curve (ROC-curve) with 95% CI. The SPSS version 20.0 for Mac and SAS 9.3 was used for analyses.

Paper II
Test of differences between groups included Fisher´s exact test for dichotomous variables (unsteadiness when walking, dizziness when turning in bed, previously falling, felling tired, not feeling well), Mantel-Haenszel chi 2 for ordered variables (number of falls) and t-tests for continuous variables (SF-36, walking speed).

Paper III
Test of differences in dichotomized variables were analyzed with logistic regression and Fisher's exact test (difference in occurrence of dizziness and falls for men and women). Means were compared between groups using t-test. Logistic regression was used for analyzing associations between dizziness and the number of medication and falls. Linear regression was used for analyzing association between number of medication and walking speed.

Paper IV
Test of differences between the groups with and without dizziness and between men and women included Fisher´s exact test for dichotomous variables (dependence of help for ADL and IADL, feeling tired, not feeling well), Mantel-Haenszel chi 2 for ordered variables (number of ADL dependency, SRH) and t-tests for continuous variables (SF-36, SOC-13), chi2 (marital status, type of housing).

The software used in paper II-IV for the statistical analysis was SPSS, and a statistics program package developed at the Department of Geriatrics at Gothenburg University (GIDSS for Windows).

3.5 Ethical considerations

All studies were conducted in accordance with the Declaration of Helsinki and were approved by the Regional Ethical Review Board in Gothenburg, Sweden. Written informed consent for study participation was obtained from all participants.

4. Results

Paper I

Two of the 15 questions in the questionnaire were of importance for diagnosing BPPV in patients seeking care for dizziness. Dizziness when laying down or turning in bed, increased likelihood of BPPV by an odds ratio 60 (95% confidence interval 7.47-481.70) on multivariate analysis. Continuous dizziness duration as opposed to lasting seconds decreased likelihood of BPPV with an odds ratio of 0.06 (0.01-0.27).

Paper II

A total of 10% of the 75-year old participants had symptoms of probable BPPV. HRQL was negatively associated with experiencing BPPV/dizziness. There were no big differences regarding HRQL, health, tiredness, falls or walking speed between persons with probable BPPV compared to those having general dizziness/impaired balance, *table 8.* Experiencing no dizziness was associated with better HRQL, less tiredness, fewer falls and higher walking speed.

Table 8. Symptoms associated with BPPV and dizziness among 75-year old compared to persons having no dizziness

	HRQL	Walking speed	Fallen last year	Number of falls	Tiredness	Feeling well
BPPV	⇩	⇩	—	⇧	⇧	⇩
Dizziness	⇩	⇩	—	⇧	⇧	⇩
No dizziness	—	—	—	—	—	—

Paper III

Dizziness at age 79 was reported among more than half of the participants with no gender differences. Approximately 40% had fallen during the past 12 months. Dizziness was related to a higher risk of falls among women (OR 2.63, 95% CI 1.67 – 4.14, p<0.0001), an association not seen among men (OR 1.07, 95% CI 0.63 – 1.82, p=0.8). Dizzy individuals had a stronger fear of falling with lower scores on (FES (S)) (p<0.01) and a higher number of medications (p<0.001) as well as diseases (p<0.001) than those without dizziness, *table 9*. Participants who reported dizziness walked slower than participants without dizziness (p<0.001). Having many medications increased the risk of falling.

Table 9. Symptoms associated with dizziness among 79-year old men and women compared to participants not having dizziness

	Falls	Fear of falling	Number of medications	Number of diseases	Walking speed
Women	↑	↑	↑	↑	↓
Men	—	↑	↑	↑	↓
No dizziness	—	—	—	—	—

Paper IV

Half of the 79-year-old participants reported problems with dizziness. Dizziness was negatively associated with HRQL (especially in the physical domain of SF-36) and self-rated health (SRH) as well as increased tiredness among both men and women. Sense of coherence (SOC) did not differ between dizzy and non-dizzy persons and no sex differences regarding SOC were seen, *table 10.*

Table 10. Symptoms associated with dizziness among 79-year-olds compared to participants not having dizziness

	HRQL	Self-rated health	Sense of coherence	Tiredness	Feeling healthy
Dizziness	⇩	⇩	—	⇧	⇩
No dizziness	—	—	—	—	—

5. Discussion

5.1 An upcoming health issue

As dizziness is so frequent in higher ages, dizziness and imbalance may become a public health issue when many countries are facing demographical changes with increasing numbers of citizens having life expectancies of 80 years and above. As part of this, dizziness, impaired balance and unsteadiness will most probably be an even bigger issue for healthcare and wellness in the forthcoming years. This demands safe and functional investigation possibilities as well as targeted treatment and rehabilitation.

Dizziness and unsteadiness are common complaints in the third part of life. In our cohort studies, we found a frequency of dizziness of 40% in the 75-year-old participants and 54% in the 79-year-old participants. The frequency of dizziness is often quite similar in the reported literature, ranging from 30-40% among older adults (>70 years) and increases in higher ages when asking for any symptoms of dizziness/faintness or imbalance on a population-based level [15, 139, 140]. We found that the occurrence of dizziness increased between age 75 and 79 among both men and women in our cohort and dizziness was reported among half of the participants at age 79. The most probable reason for this increase is the higher age of the participants but also that the question at age 79 included presence of *unsteadiness* in addition to presence of *dizziness* and *impaired balance*.

5.2 BPPV is probably both under- and overestimated

The occurrence of BPPV, which is the most common cause of peripheral dizziness, differs greatly between surveys depending on study method, research setting and age of the study participants, *table 1*. The clinical characteristics and findings of BPPV, defined as dizziness together with

canal-specific nystagmus in the Dix-Hallpike/log roll test, do not differ much between older and younger patients in respect of how to diagnose the condition, its aetiology or treatment. However, the symptoms and medical history reported by the patients may well differ. BPPV is probably both under- and overestimated. One large survey by von Brevern et al [33], frequently cited, investigated BPPV frequency on a population-based level using telephone interviews as screening method for BPPV where they asked for a history of positional symptoms [33]. This might underestimate the occurrence due to a risk of recall bias as well as older adults not always having the strong typical rotational positional dizziness seen among younger persons [22]. It might however also overestimate the frequency of BPPV as positional symptoms of dizziness is quite commonly seen with other causes of dizziness besides BPPV.

In paper II, we report a BPPV occurrence of 10% among 75-year-olds on a population-based level. However, the participants were diagnosed without the use of Frenzel goggles/videofrenzel, thus examining mainly positional dizziness equivalent of BPPV. Positional nystagmus seen without dizziness and detectable with videofrenzel, on the other hand, is not uncommon and can be found among half of healthy adults when tested with the Dix-Hallpike test, which should not be mistaken for BPPV [141]. Therefore, symptoms of dizziness during positional testing in the Dix-Hallpike/side lying test are of great importance.

5.3 Dizzy patients - a challenge for the doctor

Dizziness is a common reason for seeking medical care both in primary care as well as in the emergency department and as many as 1-2% of all visits are due to dizziness, vertigo or imbalance [13]. The dizzy patient presents a challenge for the physician as dizziness can be the result of a broad spectrum of causes, many of which are benign. Asking for dizziness when lying down or turning over can be an effective way to identify BPPV early in patients seeking care due to dizziness and vertigo, particularly in younger patients. Despite this, investigation for BPPV is not part of routine management for medical staff working with dizzy patients in the acute and elective settings in hospitals in Sweden. At Umeå University Hospital, the frequency of BPPV diagnoses almost doubled (from 8% to 15%) after introducing an algorithm in order to achieve a more

standardized investigative approach to dizzy patients, whereby more patients could receive immediate treatment [142]. The need for neuroradiological imaging also decreased after implementing standardized vestibular testing with fewer patients undergoing a CT scan and a reduction seen in the number of days with inpatients [142]. Hence, investigating and treating BPPV is both cost-effective and of great benefit to the patient.

5.4 One question might be an effective way of identifying BPPV

The first signs of BPPV are often experienced in the morning and dizziness by turning over in bed might be the initial symptom of disease. Asking about dizziness when laying down or turning over in bed together with dizziness lasting less than a minute is important when taking a medical history. In paper I, this question was singled out as most important when screening for BPPV with a sensitivity of 98% and specificity of 60%. These simple questions may help to identify potential BPPV early as well as reduce the need of further investigations. The questions are useful particularly for the general practitioner and in first line medical care, yet also in an acute setting when investigating patients with dizziness. Two examinations are necessary in order to test for BPPV; the Dix-Hallpike test and the log roll test. The tests are easy to perform but may take some time to complete especially if the dizzy patients are very nauseous and vomit. Frenzel's goggles or videofrenzel facilitate nystagmus detection. After establishing positive findings of BPPV, i.e. dizziness triggered by the positional changes together with canal-specific nystagmus, immediate treatment for the condition using the Epley's or Semont's manoeuvre is recommended, which often relieves symptoms instantaneously thereby avoiding hospitalization.

It should be emphasized, again, that the question regarding dizziness when laying down or turning over in bed might not be sufficient enough among all older patients, whose symptoms often are weaker or milder where dizziness and unsteadiness dominate primary symptomatology. Older adults additionally tend to adapt to the condition by avoiding quick head movements and by lying down slowly in order to reduce dizziness. A medical history of positional symptoms, including dizziness when lying down or turning in bed, is therefore not as common among elderly as

“On the way”, illustration by Linda Pålemo. Men tend to report better self-rated health, higher HRQL and less diseases compared to women. Women seek medical care and treatment due to falls more often than men. Men however, tend to die in fall-related injuries more often than women.

compared to the younger patients, who almost always report dizziness by positional changes. Some older adults simply avoid dizziness provoked by positional changes by sleeping in an elevated position with extra pillows and avoid turning the head backwards or forwards. Also, older adults often require a higher number of treatments to achieve cure and have a higher risk of recurrence [54]. Clinicians meeting elderly with balance problems should therefore liberally test for BPPV even though no typical history may exist. We suggest that investigation for BPPV should be considered in all older patients seeking care for unsteadiness, dizziness or imbalance after cardiac and cerebrovascular causes have been ruled out.

5.5 Occurrence of dizziness - does gender matter?

More women than men tend to report dizziness [139] and women are usually overrepresented in surveys performed in clinics investigating dizziness and balance problems [58, 61, 142]. The reasons for these gender differences are rarely discussed or explored in the existing research and literature.

Women tend to seek medical care and advice more often compared to men and are prescribed more medications [27, 143]. Men tend to report better self-rated health and HRQL and have fewer diseases compared to women [144]. Nevertheless, world-wide, women's life expectancy is higher compared to that of men albeit these differences are expected to equalize in the forthcoming years [92, 145]. So, is it just a question of attitude and habit in healthcare consumption or is the female gender more vulnerable? Oksuzyan et al presented a theory that women go from "healthy" to "unhealthy" in younger ages and tend to live longer as "unhealthy" [144]. Dizziness and vestibular disorders like BPPV and Meniere's disease are more common among women [33, 40, 146] and vestibular migraine is also reported more commonly among women compared to men [147, 148]. Women are also treated due to fall-related injuries more often than men, while men tend to die from their fall-related injuries more often than women [93, 95].

In this thesis, we found that the occurrence of dizziness was more common among women than men at age 75 but equally frequent among men and women at age 79 (papers III and IV). This is also reported by others.

” Friendship”, illustration by Linda Pålemo. A person with a strong sense of coherence (SOC) is better able to cope with stressful situations and more likely to perceive good health and HRQL, according to Antonovsky.

Hülse et al showed that dizziness and vestibular disorders were more often found among women until the age of 75 but that this gap decreased and equalized between men and women after the age of 80 [40]. The reasons for these sex differences are probably many and various. One possible explanation could be comorbidity and anxiety disorders, which are higher among women. Sex hormones are probably important, at least regarding BPPV, as we can see a post-menopausal increase in BPPV. The higher female proportion of BPPV during and after the menopause is thought to be influenced by hormonal fluctuations and changes in calcium metabolism connected with osteoporosis, even if the exact mechanism is unknown [146]. Hormonal changes can however not explain the total gender differences regarding frequency of problems with dizziness, which are most probably multifactorial.

We found that dizzy women tended to fall more often compared to non-dizzy women, which was not seen among men. Dizzy men required more help with IADL compared to non-dizzy men - a trend not seen among women. The higher dependence in ADL might indicate a decline in function. So, are men reporting dizziness in general sicker than women reporting dizziness, or does dizziness have greater impact on overall well-being and HRQL among men?

5.6 Impaired HRQL common in persons with dizziness

As mentioned in the introduction, WHO defines quality of life as *"A complete physical, mental, social well-being and not merely the absence of disease"* [77] highlighting the importance of mental well-being. It is interesting to reflect over to what extent physical function equals HRQL and measures overall well-being in persons age 75 years and above. Independence, i.e. being able to manage daily activities without help and having the ability to move around independently, is often considered an important dimension for quality of life in all ages and higher levels of physical function have been associated with higher HRQL [149]. Increased anxiety levels and fear of falling (FoF) on the other hand have been associated with frailty and reduced HRQL among older seniors regardless of results of physical tests or the number of experienced falls [114, 149].

In this thesis, we found that persons suffering from dizziness reported reduced HRQL compared to persons not reporting dizziness, as measured by SF-36 (papers II and IV). Persons with dizziness also had higher needs of IADL compared to persons without dizziness, shown in paper IV. Due to the study design, we do not know if the reduction in HRQL is secondary to morbidity or if the dizziness itself is causing the reported reduction. The SF-36 questionnaire is designed to be a multidimensional tool measuring HRQL in non-specific disease groups and is frequently used in research. However, much of the instrument targets physical function and general health, although some domains include questions focusing on psychological and mental health. The participants in the H70-studies showed higher HRQL both at 75 and 79 years of age compared to a normative population in Sweden aged 75+ [132].

Having dizziness was not associated with a reduction in SOC in paper IV. SOC targets mainly mental health and measures coping abilities. The concept of SOC is thought to explain why some people become ill in stressful situations and others remain healthy. A person with a stronger SOC is better able to cope with stressful situations and more likely to perceive good health and HRQL, according to Antonovsky. Despite the morbidity and high age of the participants, it is somewhat surprising that such a strong SOC was noted among both the dizzy and non-dizzy participants, indicative of a high overall coping capacity in the cohort and, perhaps, also acceptance and internalisation of the dizziness symptomatology.

Having dizziness was associated with higher comorbidity and more medications as well as lower self-rated health, also previously reported [151]. It is therefore tempting to assume that the higher morbidity is causing dizziness and the decline in HRQL, yet further studies exploring this relationship as a primary objective are required.

5.7 Dizziness and the risk of falling

Fall prevention is a major challenge in today's healthcare systems as falls among older adults is the trauma mechanism causing the most deaths annually and has major societal costs - a figure reaching 25 billion SEK in 2012 [94] equivalent to 10% of the total cost for the school and preschool

system in Sweden [152]. Training and exercise have been shown effective in preventing injurious falls when comparing groups receiving different interventions in order to prevent falls. [153, 154]. Unfortunately, most randomized clinical trials investigating fall prevention have a short follow up. With aging, loss of muscle mass and muscle atrophy occur. Sarcopenia, defined as progressive loss of muscle strength, is part of frailty and is a major risk for falling. Being physically active, partaking in muscle and balance training in combination with a healthy and protein rich diet as well as optimized eye-sight, may help to decrease frailty, dependence and falls, which hopefully also reduces and limits dizziness.

We found that dizziness was associated with falls among women but not among men (paper III). Higher numbers of falls were seen among persons with dizziness compared to those not having dizziness. Dizzy persons also walked more slowly than non-dizzy participants. An increased fear of falling was associated with dizziness compared to non-dizzy persons (paper III). Hence, persons afraid of losing balance and falling may reduce their physical activity in order to move slower and more carefully [110]. Unfortunately, restriction of physical activity might lead to even more sedentary behaviour, which may have adverse effects on balance. Low levels of physical activity and reduced walking speed are also more prevalent among older persons with comorbidity and frailty [109], as well as among those with symptoms of dizziness.

Having many medications was associated with falls, probably due to higher morbidity, yet potentially also as a result of polypharmacy and the drug-interactions that commonly occur. The number of medications alone might therefore be an indicator that can be used in order to pinpoint patients at risk of falling.

5.8 Dizziness in the future

Dizziness and unsteadiness in advanced ages can be caused by multiple factors, where multisensorial decline, impairment of vision, hearing, the vestibular organ and locomotion (joint, back-problems) are the most commonly reported causes [24]. It is tempting to believe that dizziness will become less frequent in the future among older adults as the population becomes healthier in higher ages. With the possibility to treat chronic diseases successfully and cure conditions like cataract, arthritis,

” Training”, illustration by Linda Pålemo. With new possibility to treat chronic diseases successfully it is possible that we will see a reduction of unsteadiness and dizziness. Staying physically active and perform exercise on a regular basis in combination with a healthy diet promotes healthy years also in high ages

hearing impairment in addition to great progress in the cardiovascular fields, it is possible that we will see a reduction of unsteadiness and dizziness at least among 70-80-year-olds. To date, the future life expectancy for a 65-years-old is an additional 20 years of which 15 years are estimated to be healthy years [92], thus indicative of a long and healthy period for most adults after retirement. Staying physically active and exercising, including balance/vestibular training, on a regular basis in combination with a healthy diet promotes healthy active years also in high ages and may reduce risk of falls [64, 68].

5.9 Strengths and limitations

Performing epidemiological research results in several strengths yet also some limitations. The strengths in the studies lie in the representative population-based sample. However, due to the cross-sectional design, the direction of causality is not possible to unveil. Due to lack of consent in the studies, we do not know why a considerable part of the invited participants declined participation. It is possible that the sickest declined study enrolment and therefore are not included in the measurements. Also, participants not speaking Swedish fluently could not partake as the survey could not provide interpreters. More participants answered questions than took part of the physical tests and filled out the self-rating questionnaires, which can also be considered a limitation. In paper II, Frenzel's goggles or videonystagmography was not used when testing for BPPV, making existing nystagmus more difficult to detect and also risking nystagmus being suppressed due to visual fixation. Nevertheless, epidemiological research from the Gothenburg H70 birth cohort studies has high clinical relevance in relation to experience of illness and understanding of symptoms. Findings from the studies will increase our understanding of ageing and, hopefully, help us to improve quality of care and symptoms of dizziness in the elderly population.

“Dix-Hallpike test”, illustration by Linda Pålemo. As BPPV is such a common condition, clinicians meeting older adults with balance problems should liberally test for BPPV even if no typical history exists. Investigations for BPPV with Dix-Hallpike/log roll test should be considered among all older patients seeking care for unsteadiness, dizziness or imbalance

6. Clinical implications

Dizziness when turning over or lying down in bed is strongly related to BPPV and asking for dizziness when turning or laying down in bed together with vertigo <1 minute are useful questions when taking a medical history which may aid early identification of patients with BPPV as well as to reduce the need of further investigations.

As BPPV is such a common condition, clinicians meeting older adults with balance problems should liberally test for BPPV even if no typical history exists. Investigations for BPPV with Dix-Hallpike/supine roll test should be considered among all older patients seeking care for unsteadiness, dizziness or imbalance after cardiac and cerebrovascular causes have been ruled out both in acute and non-acute settings.

Dizziness is associated with fear of falling and a reduction of HRQL. All possible options to reduce dizziness such as a reduction of medication, especially medications with anticholinergic effects as well as sedatives should be considered.

Treatment and improvement of vision when possible may help to reduce imbalance.

7. Conclusions

This thesis concludes that:

1. Answering “yes” to the question regarding dizziness when lying down and turning in bed is strongly associated with BPPV and may help early identification of patients with BPPV.
2. Having problems with dizziness as well as having BPPV were associated with reduced HRQL, self-rated health and more tiredness.
3. As BPPV is common among older adults and is a cause of dizziness that is potentially curable, it is important to liberally test for, and treat, the condition in order to improve HRQL and overall well-being.
4. Older adults with dizziness had more comorbidity, higher levels of dependency of IADL, walked slower and tended to fall more often than older adults without dizziness.
5. Having problems with dizziness did not affect sense of coherence as measured by SOC-13.

8. Future Perspectives

With an ageing population, dizziness may become a health issue in the future, whereby having safe, effective and feasible treatment options are important. A first step in achieving this must involve accurate testing methods for identification of structural deficits so that targeted treatment options for dizziness can be developed. In the latter years, new investigation options for vestibular testing have been developed, such as the video Head Impulse Test (vHIT) and the testing for vestibular evoked myogenic potentials (VEMP). However, both vHIT and VEMP have some disadvantages when tested in elderly people.

BPPV is the most frequently diagnosed vestibular disease causing dizziness and is a potentially curable cause of dizziness. BPPV can go unrecognized among older adults who simply adapt to the condition by avoiding quick positional changes. The true frequency of BPPV, defined as dizziness combined with canal-specific nystagmus, in the community is unknown. Current research investigating this is ongoing, which involves a population of 75-year-olds in the community and is a collaboration with Gothenburg H70 birth cohort studies.

This thesis highlights the high occurrence of dizziness among older adults. For future research it would be interesting and important to focus on interventions to reduce dizziness among older adults and to assess if an enhanced balance after training intervention in combination with vestibular training can improve HRQL and reduce symptoms of dizziness.

Impaired vision is associated with imbalance and dizziness. Improvement of vision and testing for balance before and after intervention could be interesting and might be a way to improve overall balance. An additional collaboration has been initiated, which examines hearing impairment and dizziness among older adults.

Also, a study at Södra Älvsborgs Hospital is ongoing, where geriatric patients with dizziness are tested for BPPV, vestibular deficits, walking speed, balance function and HRQL.

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Appendix

1. SF-36
2. Falls efficacy scale
3. KASAM
4. ADL-index