Does trunk acceleration variability during walking improve for elderly people following cataract surgery?

Ole Petter Norvang

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Norges tekniske og naturvitenskaplige universitet
Det Medisinske Fakultet
Institutt for samfunnsmedisin

NTNU – Trondheim
Norwegian University of
Science and Technology

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Abstract

Background; Increased trunk acceleration variability during gait may be considered as a sign of impaired dynamic postural stability. Vision is an important factor in maintaining postural stability during walking, and impaired vision has been shown to influence trunk acceleration variability.

Purpose; The aim of this study was to examine the long-term effects of cataract surgery on trunk acceleration variability during walking, in comparison to a vision-healthy control group.

Material and method; Trunk acceleration variability was investigated before and 12 months after cataract surgery, to detect changes over time and compare these between the groups. One hundred and four older adults (mean age 78.4 years, SD 4.9) undergoing cataract surgery and fifty-three vision-healthy, older controls (mean age 80.8 years, SD 3.8) were included in this study. Participants performed timed walking at preferred and fast gait speeds, and in two lighting conditions; normal and subdued, and trunk accelerations in three dimensions were measured during walking using a triaxial accelerometer. Trunk acceleration variability was calculated by using an unbiased autocorrelation procedure.

Results; In normal light at preferred gait speed there were significant differences in the changes between the cataract and the control group in all directions; AP ($p=0.01$), V ($p<0.01$), and ML ($p<0.01$). In fast gait speed no significant differences in the changes between the two groups were detected. In subdued light a similar pattern was found with significant differences in the changes between the two groups in preferred gait speed; (AP ($p=0.01$), V ($p<0.00$), and ML ($p<0.00$); but only a significant difference in the change in the vertical direction during fast gait speed.

Conclusion; The findings of this study suggest that patients improve their postural stability during walking during the year following cataract surgery.

Relevance

Postural stability amongst the elderly population is a complex challenge, and a topic that is highly relevant to persons working with rehabilitation or to prevent a drop in daily functioning for elderly. Knowledge to understand the relative role of vision correction in maintenance of postural stability (balance during walking) is important, because of the complex inter-relations between vision and trunk motion during gait, which is important for daily functioning and falls risk. With an increasing elderly population in Norway, knowledge of this will be important to prevent accidents, but also in order to prevent increasing costs following a fall and thereby an increased need for help in daily life.

1. Background

Visual impairment can influence daily activities (1-3), is associated with reduced quality of life (QoL) (4), increases incidence of falls (5, 6) and reduces overall daily distance of walking (7). The reduced distance of walking caused by visual impairment could be highlighted, since walking has been shown to be the predominant form of exercise for elderly (8). Vision is important during locomotion, and elderly people report fear of falling due to visual impairment as a reason for inactivity (9). This inactivity is likely to decrease physiological functions such as muscle strength. Combined with less ability to orient to the surroundings caused by the visual impairment, this may lead to falls (6). A visual impairment frequently reported amongst the elderly is cataract. Cataract is the main reason for blindness worldwide (10), causing 48 % of world blindness (11). The treatment of cataract is surgical, and has a high success rate (11). Cataract will influence walking, with cataract patients developing a more cautious gait, compared to subjects without cataract (12). This may be a strategy to maintain postural stability during walking, and thereby avoid falling (13). However, although some studies report reduced incidence of falls (6) and an improved postural stability (13), others report inconclusive evidence of fall prevention following cataract surgery (14). How postural stability changes following cataract surgery has just briefly been examined, and this has previously mainly been done while standing. The purpose of this study was therefore to detect how cataract surgery influences postural stability during gait.

2. Introduction

Vision is an important factor in maintaining postural stability while we move around (15-17), and help maintain postural stability and route planning during locomotion (18). Different aspects of vision, important for postural stability while walking, have been shown to be affected with increasing age. Visual acuity, contrast sensitivity, field of vision, and stereo acuity have all been connected to locomotion and falls (6). The most commonly assessed part of vision is visual acuity, or the clearness of vision, and it has been shown that improved visual acuity also improved postural stability (19). Contrast sensitivity is important to detect edges when walking (6). Field vision gives a picture of ones surroundings while walking, and visual field loss may reduce chances of navigating properly and thereby increase chances of falling (6). Therefore visual field loss has also been associated with a more cautious gait (20). Stereo acuity brings information of how far from an object the person is, thereby controlling depth in vision (21). A visual impairment known to affect gait is cataract. It is caused by the lens within the eye losing focus causing blurred vision and reducing both long distance and close up vision. The disease may also lead to problems with monocular double vision (11). There is an increasing incidence of cataract with increasing age (22). Cataract surgery is the only treatment for the disease, and is done by removal of the clouded lens, and implantation of an artificial intraocular lens (23), Visual improvements of acuity, stereopsis, and contrast sensitivity have all been reported following cataract surgery (24-26).

Outcomes of cataract surgery on daily activities are complex and in many ways difficult to assess. One of these measures is Quality of life (QoL). QoL has been argued to be an important measure following cataract surgery (27). However, the improved vision and its impact on QoL have been studied, without being able to provide a clear answer. There are studies showing an association between improvements in vision and QoL (24-26), but other studies report that QoL does not improve after cataract surgery (27, 28). Therefore, Pager et al (2004) suggested that improvement in vision, such as visual acuity, is inadequate as surgical outcome. Because walking is a main activity with increasing age, it will be an important factor of QoL. Assessing gait will therefore bring new information to the debate of improvement in QoL following cataract surgery.

Increasing age leads to changes in biomechanics and physiology, which is likely to affect activities of daily life (29). One of the activities that is likely to be affected is gait. In a study conducted by Judge et al (1996) a decline in postural stability, decreased contrast sensitivity,

decreased gait speed and decreased muscle strength were all reported as changes with increasing age that could influence gait (29). Further, visual impairments such as cataract, increase incidence as one get older (22). These changes might also have an effect on each other, thereby affecting gait. For instance, it has been shown that vision is an important factor in regulating and controlling gait speed (30). Visual impairment, such as age-related loss of visual field (31) and cataract (12) have both been associated with decreased walking speed, and measures of gait speed following cataract surgery indicate significant improvements (19, 32). Further, a study on elderly with age-related macular degeneration (ARM) has shown a relationship between impaired contrast sensitivity and decreased walking speed (33). Gait speed is an important parameter regarding mobility limitations amongst elderly, and increased gait speed in older adults is connected to a decreased mortality rate (34). In a study conducted by Stanaway and colleagues (2011), it seemed that 0.82 m/s (3km/hour) or faster is a predictor for survival (35).

An important aspect of postural stability during locomotion is variability. Measurement of gait variability has proven to provide useful insights into motor control of normal walking, age-related differences in dynamic postural stability, and gait pattern in people with movement disorders (36). Gait consists of cycles characterized by regularity, but there are also components regarding postural stability that are characterized by variability. Moe-Nilssen et al (2010) argue that different gait variability measures, both spatio-temporal and regarding trunk acceleration, represents different constructs, and that this should be included when doing gait analysis (37). Gait variability parameters are known to change with increasing age as gait gets more cautious (38). Increased stride-to-stride variability in stride length, speed and double-support has been associated with less stability and falls, and is reported with increasing age. Therefore, increased variability may be a manifestation of impaired motor control (39). Increased variability might be caused by a reduced ability to control destabilizing motion of center-of-mass of the body, and thereby be seen as a reflection of postural stability (40, 41).

One way of measuring postural stability is to measure variability of trunk acceleration during gait in three dimensions (42). A common opinion has been that postural instability primarily is present with increased variability in the medio-lateral direction in both spatio-temporal parameters (39) and in trunk acceleration (43) during walking. However, there are a few studies reporting that increased medio-lateral trunk acceleration variability is a sign of better

postural stability. Compared with healthy elderly, mobility-impaired elderly have less medio-lateral, but higher antero-posterior and vertical variability in their trunk movement while walking (43). It has been argued that medio-lateral trunk acceleration variability between strides represents a different factor of motor control compared to variability in the direction of propulsion (43). Decreased medio-lateral variability may be due to a Bernsteinian freezing of degrees of freedom where subjects decrease their degrees of freedom within a joint, to ensure greater stability. This gives a more rigid, or stereotyped, movement of the trunk (44). A possible reason for this may be that increasing age leads to decreasing muscle strength and power, thus reducing the strength to correct and control the movement (45).

Increasing age and gender both have an effect on trunk acceleration and the variability of trunk acceleration. Men tend to walk with an increased trunk acceleration in the medio-lateral direction compared to women (46). Therefore, it has been suggested that women walk with a better control strategy (46) Also when comparing variability of trunk acceleration in the medio-lateral direction, men seems to walk with an increased trunk acceleration variability compared to women (47). Because of this gender difference it has been argued that gender should be considered when assessing upper body kinematics (46). There is also reported an age-associated difference in elderly walking with less magnitude of acceleration in all three directions compared to younger participants (38). It has also been reported age-associated differences related to medio-lateral stability of center of mass, with older age leading to less postural stability (48). Since increasing age and an increased incidence of falls is associated with a more cautious gait (38, 45), trunk acceleration variability will be affected with increasing age.

Impaired vision seems to have an effect on postural stability, but a clear conclusion regarding variability of trunk acceleration during gait is missing. Several studies have looked upon postural stability in subjects with impaired vision, and it has been reported less trunk flexion (16), and smaller trunk acceleration in all three directions (38) in subjects with visual impairments. Cataract also seems to affect postural stability, and cataract surgery has shown to be beneficial in regard to postural stability while standing (13, 19, 49). In an experimental trial where they compared normal vision with blurred vision simulating cataract, displacement of center of pressure was decreased from normal to blurred vision in a stepping task, suggesting a more cautions strategy to increase postural stability (50). However, trunk

acceleration variability as a measure for postural stability during gait for subjects with visual impairments is still not clear.

Lighting conditions that reduces vision has been shown to affect trunk acceleration, the variability of trunk acceleration, and gait speed during walking. In darkness, vision will give less feedback, making us rely more on other senses to maintain postural stability. Iosa et al (2012) found that walking in darkness increased both antero-posterior and medio-lateral trunk acceleration, compared to normal light when they examined effects of visual deprivation on gait dynamic stability (51). However, Helbostad et al (2009) found no effect of subdued light regarding trunk acceleration variability, compared to walking in normal light (47). Another adjustment done in darkness is to reduce gait speed. In a study conducted by Anat et al (2005), subjects regardless of gait disorder walked with slower gait speed in reduced lighting compared to walking in full lighting, suggesting an adaptation to a more cautious gait (52).

The influence of gait speed on trunk variability is debated. Kang and Dingwell (2008) has shown that elderly people had significantly greater trunk movement variability during walking than younger people, independent of changes in speed, suggesting that variability was caused by something other than gait speed (53). However, there are studies showing a clear relationship between trunk acceleration variability and gait speed. In a study conducted by Kavanagh (2009) looking at variability of trunk acceleration, results suggest an increase in medio-lateral and vertical direction during slow speed walking, compared to preferred and fast speeds (54). In a study conducted by Helbostad et al (2003), a curvilinear relationship was shown between gait speed and trunk acceleration in medio-lateral, antero-posterior, and vertical directions. They argue that gait speed is a confounding factor and needs to be controlled for (55).) The role of gait speed on trunk acceleration variability during gait is not clear, but it seems to be a parameter one needs to consider when examining trunk acceleration variability.

The association between vision and trunk acceleration variability is likely to be complex. Vision provides information about the surroundings, and one might expect visual impairment to lead to a more cautious gait, and less trunk variability. However, because visual impairment also might lead to less postural stability, increased trunk acceleration variability may also result from visual impairment. Gait characteristics regarding postural stability following

cataract surgery has not been examined, and the effect surgery has on trunk acceleration variability during gait is as yet unknown.

The broad study aim was to investigate if cataract surgery improves trunk acceleration variability by firstly comparing the change in trunk acceleration variability during walking from before to one year after cataract surgery with a healthy-vision control group, not undergoing surgery. Secondly, the study aimed to assess changes in the cataract group more in depth. The study questions were:

Primary

1. Are there between group differences in the changes in antero-posterior, vertical and medio-lateral direction in trunk acceleration variability during walking between strides in normal light during preferred gait speed from baseline to 12-month follow-up?

Secondary

1. Are there between group differences in the changes in trunk acceleration variability in three dimensions during walking at fast gait speed in normal light from baseline to 12-month follow-up?

2. Will trunk acceleration variability during walking in subdued light follow the same pattern of change for the older people who underwent cataract surgery as in normal light?

3. Are there baseline differences in trunk acceleration variability between the cataract and the control group?

4. To what degree can change in vision or change in walking speed explain the changes in trunk acceleration variability between strides during walking following cataract surgery?

It was hypothesized that older people who have undergone cataract surgery will increase their medio-lateral, but decrease their antero-posterior and vertical trunk acceleration variability during gait relative to the control group. This is based on previously reported cross-sectional findings using the same method as in this study, suggesting that elderly people with postural instability have lower medio-lateral, but higher antero-posterior and vertical trunk acceleration variability than healthy elderly (43), and cataract induced poor vision was expected to have a similar effect on the trunk acceleration variability as postural instability. Walking in subdued light had no effect on trunk acceleration variability compared to normal light in a previous study (47). Therefore, although vision in subdued light provides less visual

feedback and thereby would reduce importance of surgery to correct vision, it is expected that trunk acceleration variability will develop as in normal light with increased medio-lateral, and decreased antero-posterior and vertical trunk acceleration variability following cataract surgery. Finally, as previously reported, gait speed increases (19, 32) and vision improves (24, 25) following cataract surgery, and one would expect that change in gait speed and change in vision to a certain degree could explain any changes in trunk acceleration variability.

3. Method

3.1 Design

The present study is a sub study of the study "Reduced vision, balance and gait control as risk factors for falling in the elderly", performed by researchers from The Department of Neuroscience, Norwegian University of Science and Technology, Trondheim, Norway during 2005-2006.

The study was performed as a longitudinal prospective case-control study over one year, with older persons referred to cataract surgery as cases (cataract group), and older persons with good vision for their age, matched for age and gender as controls (control group). The study is registered in the ClinicalTrials.gov with trial number NCT00218894.

3.2 Participants

In the original study, 200 people were invited to participate in the cataract group, and 168 persons in the control group. Persons over the age of 70 years referred to St Olav University Hospital for cataract surgery were eligible for inclusion in the cataract group. Persons matched for age and gender, home-dwelling in the municipality of Trondheim, were eligible for inclusion in the control group.

Inclusion criteria for participants in either group were:

- Be able to walk at least 10 meters without assistance from another person or walking aids
- Living independently in their home

Exclusion criteria were:

- Mini Mental Status Examination scores <20/30 (56)
- Terminal illness at the time of recruitment
- Suffering stroke or undergone knee or hip surgery during the six months prior to recruitment.

For the cataract group, unilateral or bilateral cataract had to be their primary reason for visual impairment. For the control group, an additional inclusion criteria was that they had not undergone cataract surgery before.

This study is based on data from the original study. However, in addition to the inclusion criteria mentioned, participants also had to be tested at both baseline and 12-month follow-up. Figure 1 shows flow chart from the original study to the study presented here.
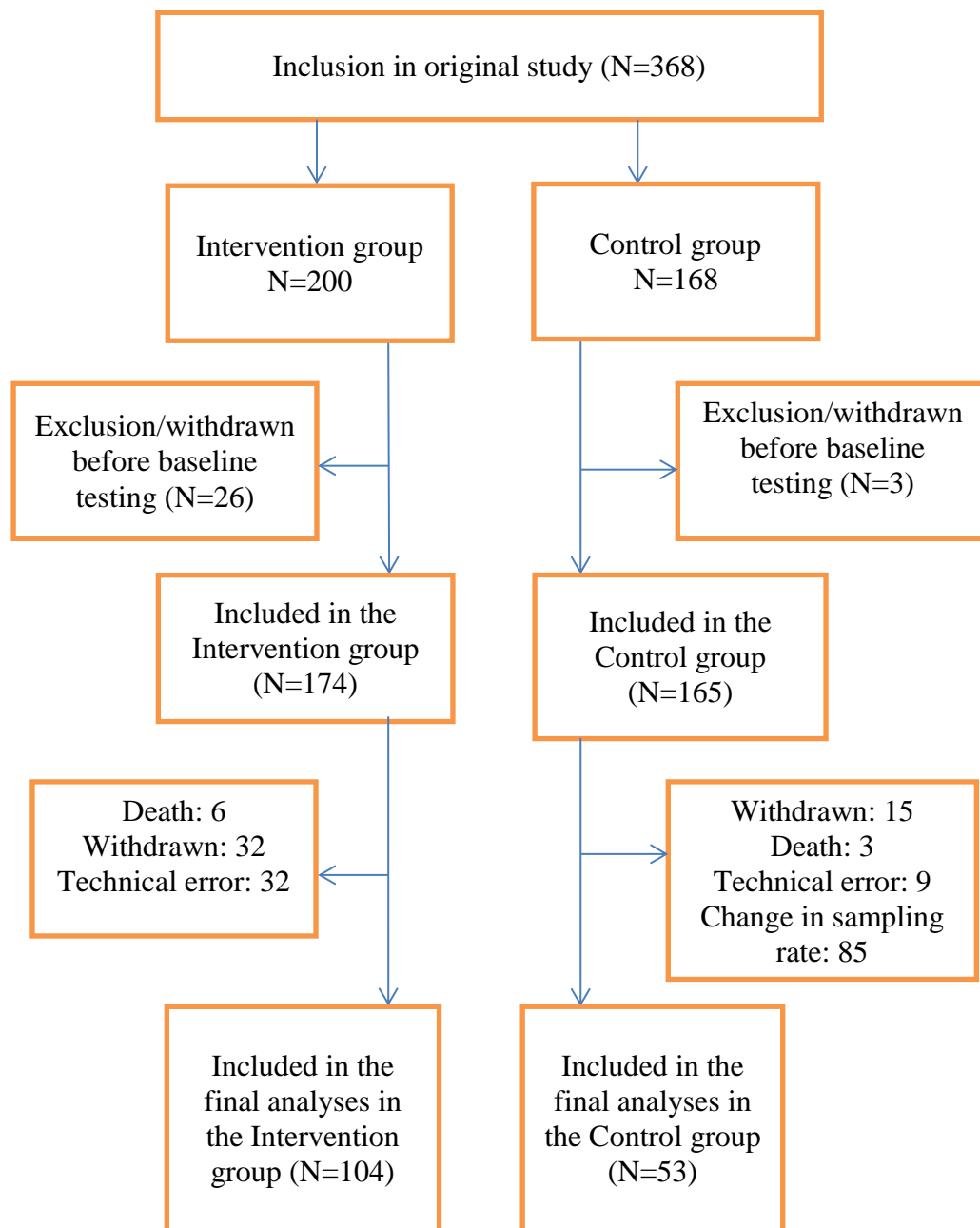
11

Figure 1. Flow chart of the participants, from the original study to the study present here

3.3 Procedure

The cataract group was tested 1-3 weeks in advance of the surgery, and 12 months after surgery. The control group was tested at inclusion and 12 months later.

All patients referred to the Cataract Unit were sent written information and an invitation to participate in the "Reduced vision, balance and gait control as risk factors for falling in the elderly" study with their appointment for pre-surgery assessment at the Eye Clinic. Surgery on the first eye was performed within a week after baseline testing. Participants were re-tested 12 months after surgery on the last operated eye.

Eligible persons for both groups completed an opthalmogic assessment and were screened for inclusion. Within a week after screening, eligible participants were given a medical examination and assessment of postural stability and gait, and answered questions on their health and functioning. Ophthalmological assessment was done by an ophthalmologist, whereas the general medical assessment was done by a geriatrician. To assess cognitive function, the Mini-Mental Status Examination was used. Those fulfilling the inclusion and exclusion criteria were invited to a 12-month follow-up assessment.

Gait was tested on a 7 meter long walkway, where participants walked back and forth over the walkway at two different gaits speeds in a normal light condition (>250 lux) and in a subdued light condition (5-10 lux), giving a total of 8 walks. The conditions were:
- Preferred walking speed in normal lighting
- Fast walking speed in normal lighting
- Preferred walking speed in subdued lighting.
- Fast walking speed in subdued light

Instructions for gait speed given before walking in both normal and subdued light were as follows:
"Walk at a preferred speed as you normally walk inside".
"Walk as fast as you safely can, without running".

All participants waited 2 minutes from the light was subdued before starting to walk, to adapt their vision to the change in lighting condition (47, 57).

13

3.3.1 Gait speed

Gait speed over the middle 4.7m of the 7m walkway was measured using electronic photo cells, by dividing the distance walked by the time it took to walk it. Mean gait speed was calculated for each speed and lighting condition.

3.3.2 Trunk acceleration

While walking participants wore a triaxial piezoresistant accelerometer over the L3 region of the lower back, recording acceleration along three axes of the trunk. Figure 2 shows the equipment used in this testing with the accelerometer, the memory flash card, cable, accelerometer, and elastic belt. Data were stored on a battery-operated portable data logger connected to the accelerometer. To reduce interference, signals were low-pass filtered at 55 Hz before being sampled at 128 Hz. Signals were transferred to a computer for further processing.

When a piezoresistant accelerometer is tilted out of the horizontal plane, it measures gravity as well as dynamic acceleration. Because the accelerometer is attached over the lumbar spine, it may be tilted due to the lumbar curvature. This may lead to measuring some degree of gravitational acceleration which must be corrected for in order to assess true dynamic acceleration during gait. These mathematical corrections were done in a horizontal-vertical coordinate system and reported elsewhere (58). The instrument has previously been tested for precision and accuracy (58).
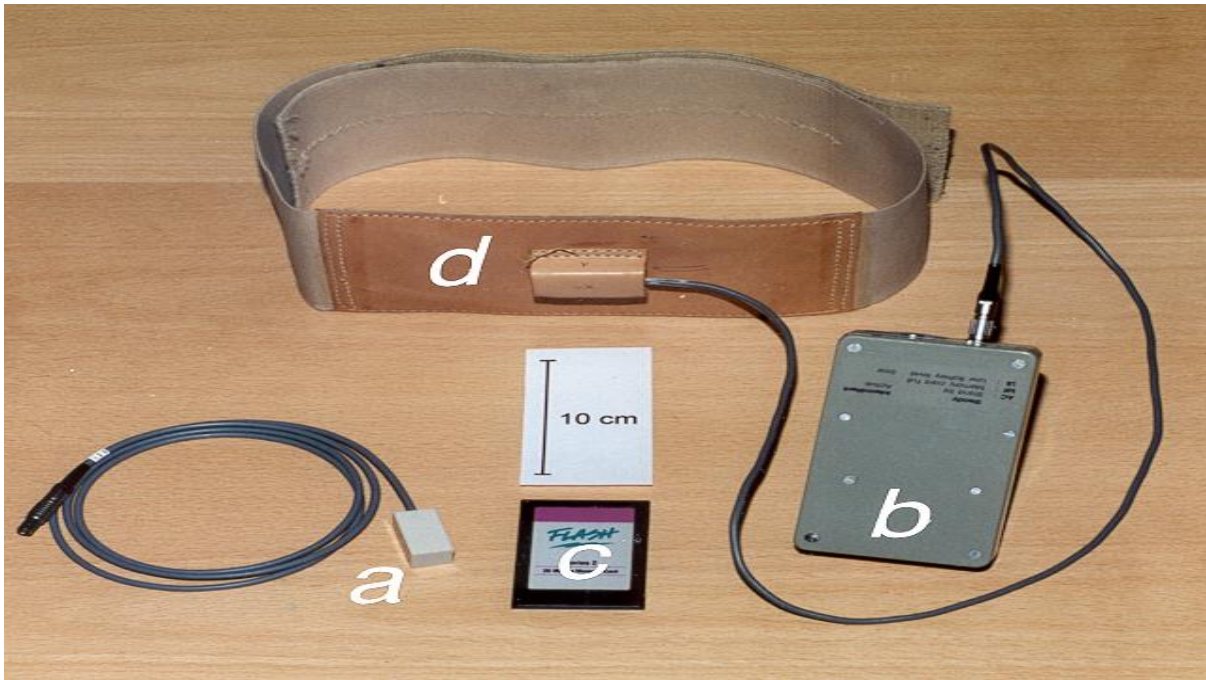
Figure 2: Accelerometer with a cable (a), accelerometer (b), memory flash card (c), and elastic band (d).

3.3.3 Cataract surgery

All participants in the cataract group received the same surgical technique (phacoemulsification) under anesthesia through a 2.75 mm scleroscorneal incision using a standardized technique. Intraocular lenses (IOL) or silicon 3-piece asheric were implanted. Single-piece IOLs were chosen when participants had an age-related systemic disease (pseudoexfoliation) or the same IOL in the other eye. Target of refraction was emmetropia or isometropia. All operations were performed by the same surgeon. For those having surgery on both eyes, the surgery on the second eye was performed within 2 weeks of surgery on the first eye (59).

3.3.4 Testing of vision

For both the cataract and the control group, measurements of visual acuity were done using the EDTRS logMAR chart, presented 4 metres in front of the subject and reported as the best corrected binocular acuity (logMAR) (60). Binocular contrast vision was assessed in full light (Photopic contrast >250 lux) and in subdued light (Mesophic contrast; 8-10 lux) by a Pelli-Robson-chart (logMAR) (61). To measure visual field, a Humprey Field Analyzer (SITA fast) was used on both eyes (mean deviation from normal from each eye) (62). Visual field was

only tested in the cataract group, and only at baseline. Stereo acuity was assessed by a Stereo II Test, and scored on a scale from 0-3, with 3 as the best score (63). Figure 3 illustrates the vision tests used in this study.
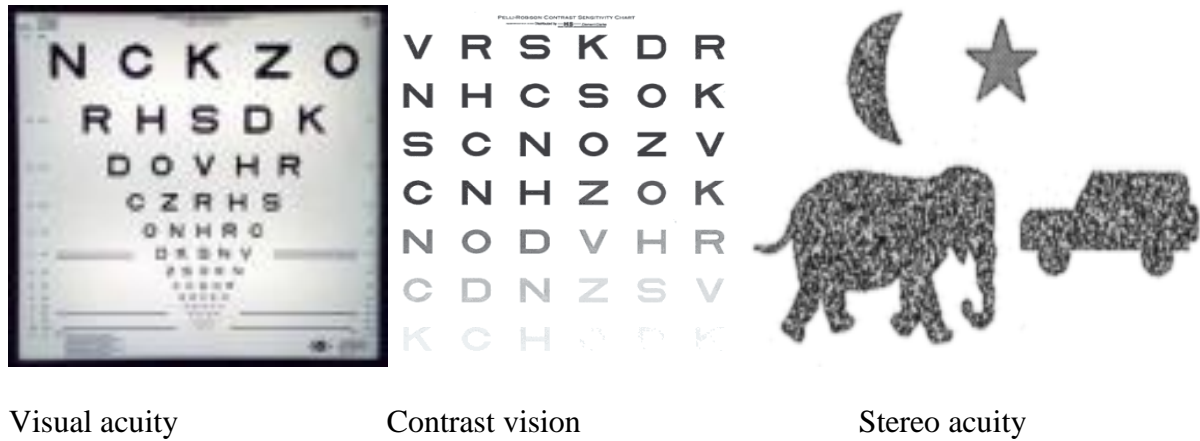

Visual acuity   Contrast vision   Stereo acuity

Figure 3: Testing of visual parameters

3.4 Outcome measures

The primary endpoints were differences in between stride variability of acceleration signals in antero-posterior (AP), vertical (V), and medio-lateral (ML) directions between the two groups.

Gait speed (m/s) at preferred and fast gait speed for the normal light and the subdued light condition was measured using electronic photo cells and a computerized stopwatch.

Vision variables included in the analysis were binocular corrected visus (logMAR), photopic and mesopic contrast sensitivity (logMAR), and stereopsis (0-3).

3.5 Data processing

Acceleration data were processed in Matlab 7.1. Data from the accelerometer was transformed into a vertical-horizontal coordinate system (consisting of AP, V and ML) and RMS values were calculated. Data were then transferred to Excel by the Matlab toolbox Excel-link. Figure 4 shows raw acceleration signal for AP, V and ML axes captured during a gait sequence. To find variability of acceleration between strides, an unbiased autocorrelation coefficient was calculated. This was obtained by correlating the overlapping parts of

acceleration time series representing a walking trial and a replication of the same time series at a phase shift equivalent to one stride. Figure 5 shows this replication, with first having two identical time series on top of each other, before shifting one of them equivalent to the next stride. A perfect replication of the gait cycle signal between neighboring strides will return an autocorrelation coefficient of 1, and no association a coefficient of 0. The procedure has previously been described by Moe-Nilssen and Helbostad (2004) (42). Autocorrelation measures repeatability of acceleration signals between strides. However, in the literature the concept variability is more commonly used. 1- repeatability indicates variability, and the term variability will be used when describing the measured autocorrelation in the remainder of the thesis.
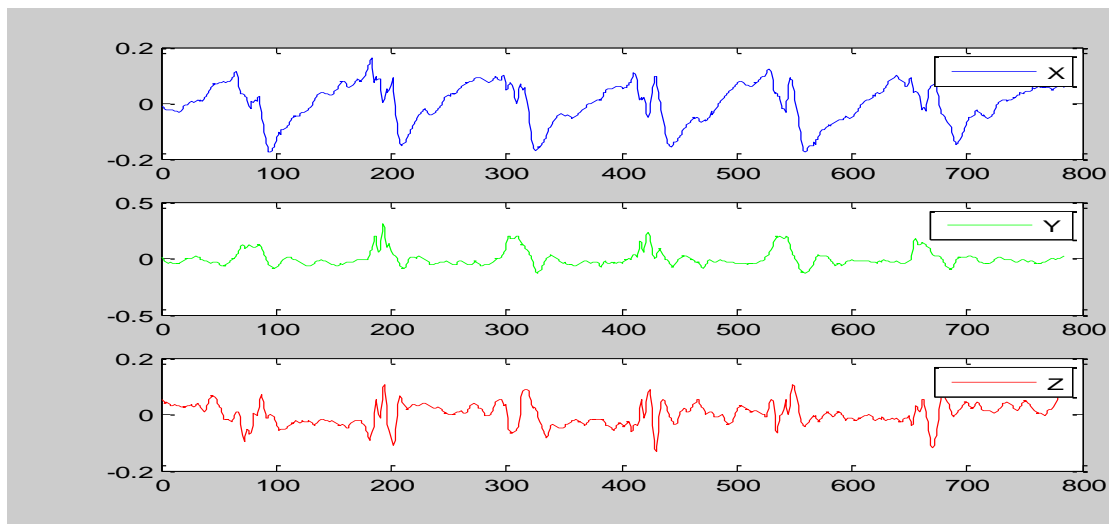

Figure 4. Raw acceleration signals during gait data in antero-posterior (blue), vertical (green) and medio-lateral (red) direction.
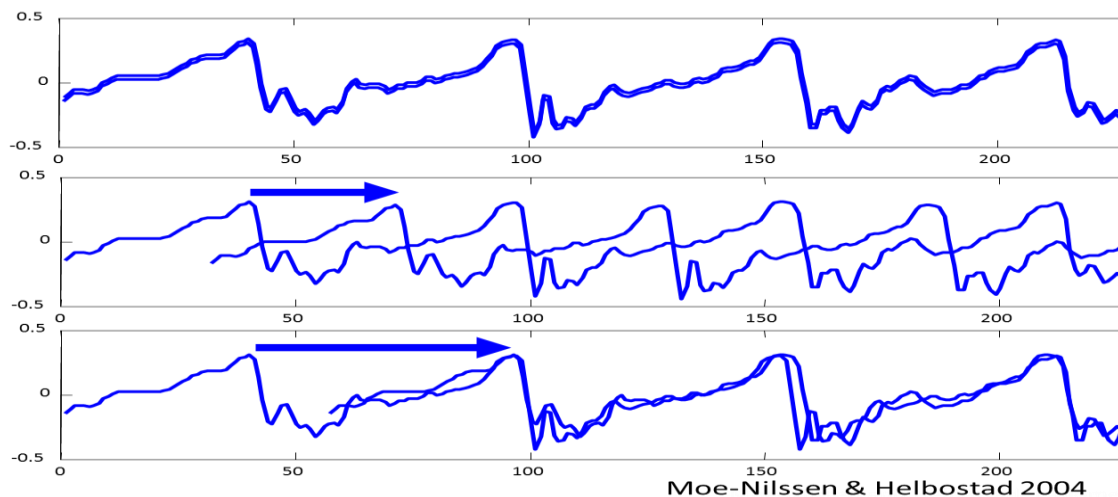
17

Figure 5. Autocorrelation procedure. Two identical time series lies on top of each other, before one of them are been shifted to the right and then overlapping the next stride. Higher overlapping gives a high autocorrelation coefficient.

3.6 Statistical analyses

Statistical analyses were done in Microsoft Excel 2010 and SPSS 20.0 for Windows. Chi-square t-tests were used to detect significant differences between the two groups at baseline regarding diseases and gender, whereas t-tests were used to detect other significant differences between the two groups at baseline. When detecting background differences between the two groups, a significance level of 0.05 was chosen. An alpha level of $p < 0.0125$ was selected for statistical significance, to avoid type I errors when looking at trunk acceleration variability and gait speed. A common alpha level for statistical significance is 0.05, but because of multiple testing with two lighting conditions and two different gait speeds the probability of making a type I error is increased by 4. To assess differences in between-group changes in trunk acceleration, an ANOVA analysis was performed. To check for within group changes in trunk acceleration variability, vision and gait speed from baseline to 12-month follow-up, paired samples t-tests were used. Bivariate linear regression analyses were done to examine to what degree change in vision or change in gait speed separately could explain any changes in trunk acceleration variability found.

3.7 Ethical considerations

Participation was voluntary, and all participants signed an informed consent form.The study was approved by the Regional Committee on Ethics in Medical Research in Central Norway

with registration number 10567 and the Norwegian Social Science Data Service. During testing, one tester walked next to the track to ensure that participants did not fall. Collected data was anonymized before being securely stored.

4. Results

A total of 157 participants with a mean age of 79.2 years (±4.7) participated, 104 in the cataract group and 53 in the control group. Table 1 and 2 shows baseline characteristics for the participants in both groups. Independent sampled t-tests were used to detect differences between the two groups. There were 54 men and 103 women in total and a significant gender difference between the groups (p=0.01). There were also significant age and height differences between the groups, with older (p<0.01) and taller participants (p=0.01) in the control group. Field vision sinister at baseline in the cataract group was -1.30 (SD 3.17) and -1.86 (SD 3.03) at dexter. Table 2 shows the number of participants with specified diseases. The cataract group in general had a higher percentage of diseases except for cancer.

Table 1. Characteristics of the participants and significant group differences (t-test except for gender chi-square)

	Cataract (N=104)	Control (N=53)	Group differences (p-value)
Age at inclusion, years (mean ± SD)	78.4 ±4.9	80.8 ±3.8	-3.23 (<0.01)*
Gender male N (%)	28 (26.9 %)	26 (49.1 %)	2.81 (0.01)*
Height, cm (mean ± SD)	162.6 ± 7.6	166.6 ± 10.0	-2.83 (0.01)*
Weight, kg (mean ± SD)	71.9 ± 14.0	75.6 ± 13.9	-1.60 (0.11)
BMI (mean ± SD)	27.0 ± 4.5	27.1 ± 3.3	-0.19 (0.85)
MMS (mean ± SD)	27.3 ± 2.5	27.5 ± 2.9	-0.45 (0.65)

* Significant at p<0.05.

Table 2. Baseline incidence of common diseases and significant group differences between the groups (chi-square)

	Cataract N (%)	Control N (%)	Sign. group difference X^2 (p-value)
Heart disease, N (%)	33 (31.7)	17 (32.1)	<0.01 (0.97)
Chronic obstructive lung disease	17 (16.3)	3 (5.7)	3.61 (0.06)
Diabetes mellitus	11 (10.6)	0 (0.0)	6.03 (0.01)*
Cerebral infarction	6 (5.8)	3 (5.7)	<0.01 (0.98)
Cancer	7 (6.7)	11 (20.8)	6.80 (0.01)*
Rheumatism	12 (11.5)	4 (7.5)	0.61 (0.43)
Sjøgrens/sicca	2 (1.9)	0 (0.0)	1.03 (0.31)

* Significant at p<0.05

4.1 Gait characteristics in normal light

*Table 3. Gait variability (autocorrelation coefficient) in **normal light** at baseline and 12-month follow-up for the cataract group and the control group.*

	Cataract group			Control group			Between group differences	
	Baseline	**12 months**	**Difference pre/post**	**Baseline**	**12 months**	**Difference pre/post**	**Between group differences**	
	Mean (SD)	Mean (SD)	Mean change (p-value)	Mean (SD)	Mean (SD)	Mean change (p-value)	Diff mean change (95% CI)	F (p-value)
Preferred gait speed								
AP trunk variability	0.73 (0.11)	0.75 (0.13)	-0.02 (0.09)	0.79 (0.11)	0.76 (0.11)	0.03 (0.02)	0.05 (-0.01, -0.09)	6.90 (0.01)*
V trunk variability	0.69 (0.16)	0.72 (0.17)	-0.03 (0.02)	0.78 (0.15)	0.73 (0.15)	0.05 (<0.01)	0.08 (-0.04, -0.14)	12.62 (<0.01)*
ML trunk variability	0.47 (0.15)	0.52 (0.16)	-0.05 (<0.01)	0.57 (0.17)	0.54 (0.17)	0.03 (0.07)	0.09 (-0.04, -0.13)	13.26 (<0.01)*
Fast gait speed								
AP trunk variability	0.73 (0.13)	0.71 (0.13)	0.02 (0.22)	0.77 (0.12)	0.74 (0.11)	0.03 (0.05)	0.01 (0.04, -0.06)	0.23 (0.64)
V trunk variability	0.78 (0.14)	0.77 (0.15)	0.01 0.55)	0.84 (0.10)	0.80 (0.12)	0.04 (<0.01)	0.03 (0.01, -0.08)	2.17 (0.14)
ML trunk variability	0.60 (0.16)	0.59 (0.16)	0.01 (0.62)	0.65 (0.13)	0.59 (0.13)	0.06 (<0.01)	0.06 (0.01, -0.10)	2.26 (0.14)

AP=antero-posterior, V=vertical, ML=medio-lateral, SD= standard deviation, CI= confidence interval. *significant at p<0.0125

4.2 Gait characteristics in subdued light

*Table 4.Gait variability (autocorrelation coefficient) in **subdued light** at baseline and 12-month follow-up for the cataract group and the control group.*

	Cataract group			Control group				
	Baseline	**12 months**	**Difference pre/post**	**Baseline**	**12 months**	**Difference pre/post**	**Between group differences**	
	Mean (SD)	Mean (SD)	Mean change (p-value)	Mean (SD)	Mean (SD)	Mean change (p-value)	Diff mean change (95% CI)	F (p-value)
Preferred gait speed								
AP trunk variability	0.76 (0.12)	0.78 (0.11)	-0.02 (0.07)	0.78 (0.12)	0.75 (0.14)	0.03 (0.05)	0.05 (-0.01, -0.09)	7.25 (0.01)*
V trunk variability	0.74 (0.15)	0.78 (0.13)	-0.04 (0.01)	0.79 (0.14)	0.76 (0.14)	0.03 (0.16)	0.07 (-0.02, -0.11)	7.22 (0.01)*
ML trunk variability	0.55 (0.16)	0.60 (0.14)	-0.04 (<0.01)	0.63 (0.13)	0.56 (0.13)	0.07 (<0.01)	0.11 (-0.06, -0.17)	18.14 (<0.01)*
Fast gait speed								
AP trunk variability	0.77 (0.11)	0.76 (0.10)	0.01 (0.11)	0.78 (0.11)	0.75 (0.12)	0.03 (0.04)	0.02 (0.05, -0.02)	0.52 (0.47)
V trunk variability	0.81 (0.12)	0.82 (0.11)	-0.01 (0.31)	0.85 (0.10)	0.79 (0.15)	0.06 (0.01)	0.07 (-0.02, -0.10)	10.35 (<0.01)*
ML trunk variability	0.62 (0.16)	0.62 (0.15)	0.00 (0.97)	0.65 (0.14)	0.60 (0.16)	0.05 (0.01)	0.06 (-0.01, -0.11)	5.21 (0.02)

AP=antero-posterior, V=vertical, ML=medio-lateral, SD= standard deviation, CI=confidence interval. *significant at $p < 0.0125$
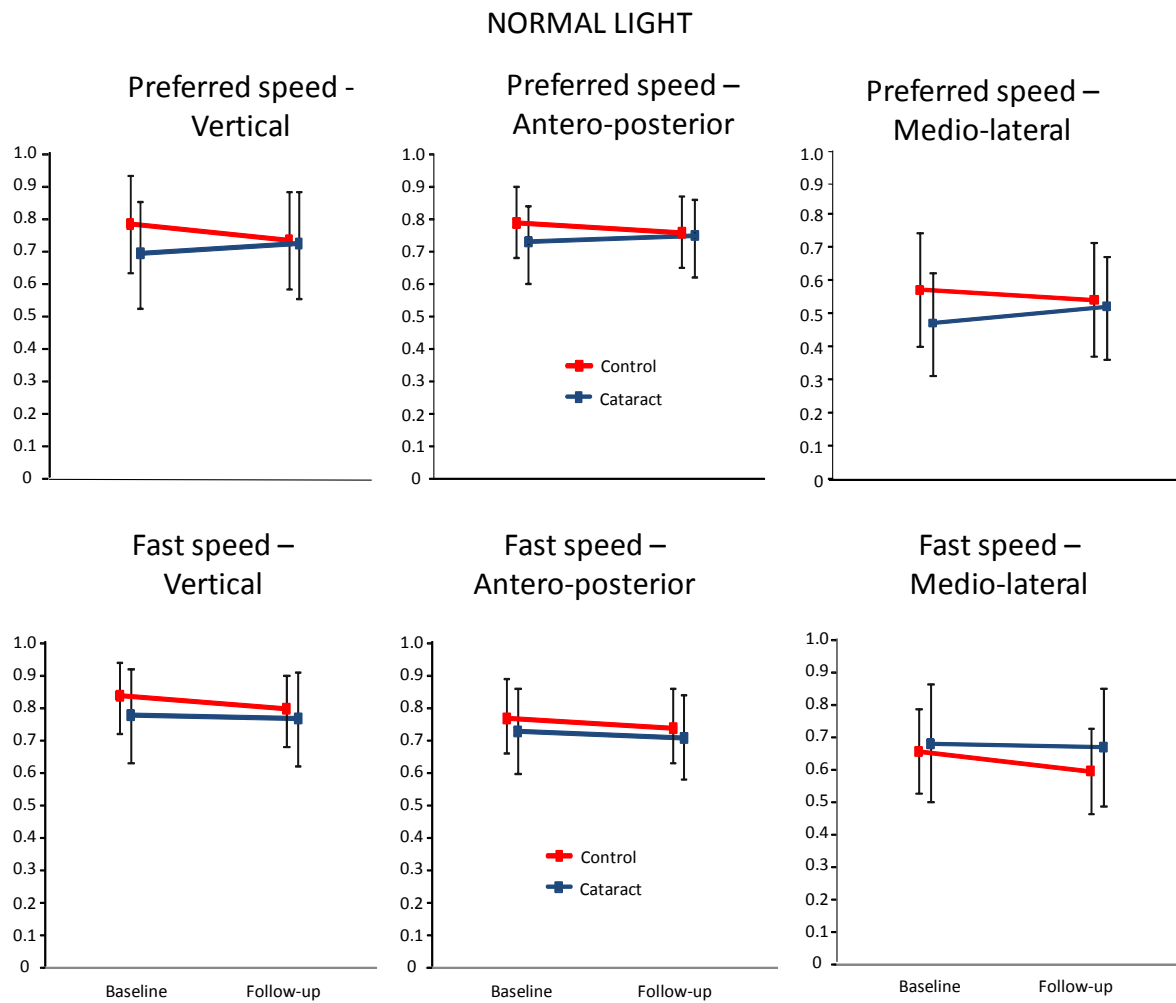
*Figure 6. Cataract and control group at baseline and at 12-month follow-up in **normal light** with trend lines between baseline and follow-up. Higher values indicate lower variability.*
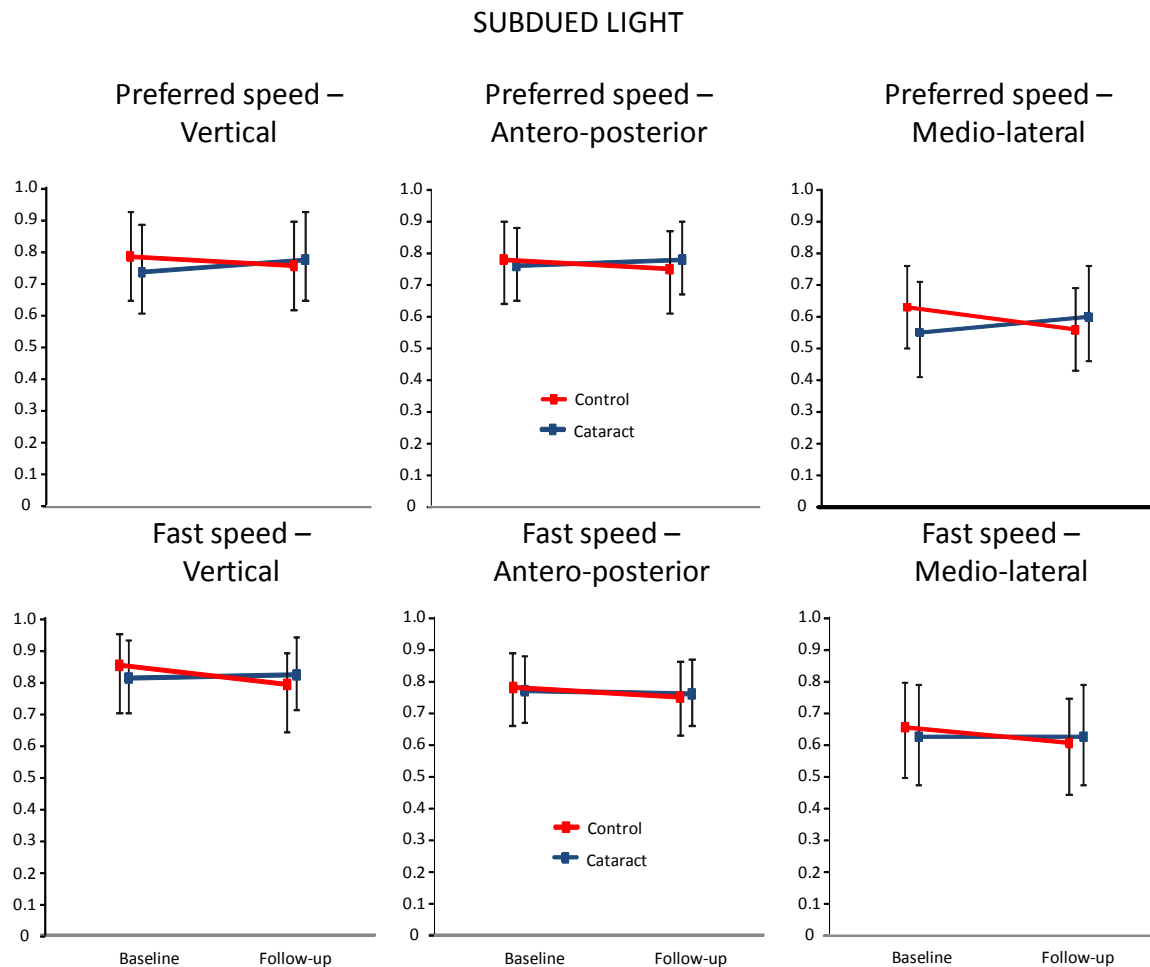
*Figure 7. Cataract and control group at baseline and at 12-month follow-up in **subdued light** with trend lines between baseline and follow-up. Higher values indicate lower variability.*

Table 3 shows trunk acceleration variability during gait in normal light at baseline and 12-month follow-up. There were significant differences in the changes between groups in all three directions for preferred gait speed. There is a trend within the two groups were the cataract group decrease their trunk acceleration variability and the control group increase theirs. However, except for the medio-lateral direction in the cataract group and in vertical direction in the control group, these changes are not significant. This is illustrated in figure 6, where the difference between the two groups at baseline decreased in all three directions by the 12-month follow-up. In fast gait speed no significant in the changes were found in any direction between the two groups. The same trend regarding trunk acceleration variability within the two groups was seen in here, but except for vertical and medio-lateral direction in the control group, these changes were not significant. Within the groups in preferred gait speed the cataract group showed a significant decrease in mean trunk acceleration variability in the medio-lateral direction (mean=-0.05, p<0.01) during preferred gait speed. In the control

group, significant increase of trunk acceleration variability was found in vertical (mean=0.05, $p<0.01$) direction during preferred gait speed. In fast gait speed there were no significant changes in the cataract group. In the control group both vertical (mean=0.04, $p<0.01$) and medio-lateral (mean=0.06, $p<0.01$) direction had a significant increase in trunk acceleration variability.

Table 4 shows trunk acceleration variability in subdued light at baseline and 12-month follow-up. Significant differences in the change over time in all directions were found at preferred gait speed. Figure 7 shows how the two groups changed from baseline to the 12-month follow-up. Trends within groups regarding changes are the same here as in normal light, but except vertical and medio-lateral direction in the cataract group and medio-lateral direction in the control group during preferred gait speed. In fast gait speed only vertical and medio-lateral directions in the control group were significant. In fast gait speed only the vertical trunk acceleration variability change was significantly different ($p<0.01$) when comparing the changes between the two groups. Trends between the two groups are similar to those in preferred gait speed. The cataract group showed a small, but significant increase in vertical (mean=-0.04, $p=0.01$) and medio-lateral (mean=-0.04, $p<0.01$) direction in preferred gait speed. In the control group, significant difference was found in the medio-lateral (mean=0.07, $p<0.01$) direction in preferred speed. In fast speed, no significant changes were found within the cataract group, but in the control group both vertical and medio-lateral direction increased significantly (both $p=0.01$).

Table 5: Gait speed in normal and subdued light at baseline and 12-month follow-up for the cataract and the control group.

Normal light	Cataract group			Control group			Between group differences		
	Baseline	12 months	Difference pre/post	Baseline	12 months	Difference pre/post	Change in mean difference		Group difference
	Mean (SD)	Mean (SD)	Mean (p-value)	Mean (SD)	Mean (SD)	Mean (p-value)	Diff (SE)	Confidence interval	F (p-value)
Preferred gait speed (units)	0.89 (0.21)	0.89 (0.20)	0.00 (0.29)	0.94 (0.24)	0.81 (0.21)	-0.13 (<0.01)	0.13 (0.02)	0.11, 0.16	116.98 (<0.01)*
Fast gait speed (units)	1.23 (0.29)	1.45 (0.36)	0.22 (<0.01)	1.30 (0.33)	1.09 (0.28)	-0.21 (<0.01)	0.43 (0.03)	0.38, 0.48	201.02 (<0.01)*

Subdued light	Cataract group			Control group			Between group differences		
	Baseline	12 months	Difference pre/post	Baseline	12 months	Difference pre/post	Change in mean difference		Group difference
	Mean (SD)	Mean (SD)	Mean (p-value)	Mean (SD)	Mean (SD)	Mean (p-value)	Diff (SE)	Confidence interval	F (p-value)
Preferred gait speed (units)	0.93 (0.19)	0.93 (0.19)	0.00 (0.01)	1.02 (0.24)	0.84 (0.20)	-0.18 (0.11)	0.18 (0.01)	0.16, 0.20	274.86 (<0.01)*
Fast gait speed (units)	1.20 (0.27)	1.47 (0.30)	0.27 (0.17)	1.32 (0.33)	1.06 (0.26)	-0.26 (0.13)	0.52 (0.03)	0.47, 0.58	381.72 (<0.01)*

* Significant p< 0.0125

Table 6: Vision at baseline and 12 months for the cataract group and the control group.

Vision test	Cataract group			Control group			Between group differences		
	Baseline	**12 months**	**Difference pre/post**	**Baseline**	**12 months**	**Difference pre/post**	**Change in mean difference**		**Group difference**
	Mean (SD)	Mean (SD)	Mean (p-value)	Mean (SD)	Mean (SD)	Mean (p-value)	Diff (SE)	Confidence interval	F (p-value)
Visus corrected	0.65 (0.21)	1.12 (0.28)	0.47 (0.000)	1.01 (0.21)	0.99 (0.19)	-0.03 (0.26)	0.50 (0.04)	0.41, 0.58	132.42 (<0.01)*
Photopic	1.51 (0.15)	1.65 (0.14)	0.14 (0.000)	4.84 (22.87)	4.58 (20.77)	-0.27 (0.37)	0.40 (0.30)	0.18, -0.99	3.70 (0.18)
Mesopic	1.30 (0.20)	1.51 (0.19)	0.21 (0.000)	4.52 (20.78)	4.53 (20.78)	0.01 (0.71)	0.19 (0.04)	0.13, 0.13	28.72 (<0.01)*
Stereopsis	1.14 (1.19)	1.69 (1.14)	0.55 (0.000)	1.65 (1.44)	2.16 (1.26)	0.51 (0.03)	0.04 (0.25)	-0.44, 0.53	0.03 (0.87)

* Significant p< 0.05

Table 5 shows change in gait speed between groups and within both groups. In both normal and subdued light changes from baseline to one year follow-up are all significant (p<0.01 for all variables). In normal lighting condition, preferred gait speed within the cataract group does not seem to change, but there is a significant increase in fast gait speed between baseline and 12 months (mean=0.22, p<0.01). In the control group there is a significant decrease in both preferred (mean=-0.13, p< 0.01) and fast (mean=-0.21, p<0.01) gait speed in normal light. In subdued lighting there is a significant increase in gait speed within the cataract group (p<0.00), but no significant change in fast gait. No significant differences were found within the control group in subdued light.

4.3 Change in vision pre/post

Table 6 shows change in vision function between baseline and 12 months. Significant changes between the two groups were found in visus corrected and in contrast sensitivity in reduced light (mesopic light) (p<0.01), but not in photopic light and in stereopsis. The cataract group showed significant increase for all four vision conditions (p<0.01 in all conditions), whereas the control group had no significant changes.

4.4 Associations between change in trunk acceleration variability and change in vision and gait speed

Table 8. The associations (R^2) between change in gait speed or vision with change in trunk acceleration variability in the cataract group. (The analysis was only carried out where significant changes over time were found for the trunk acceleration variability measures.)

	Change in ML trunk acceleration variability (preferred speed, normal light)		Change in V trunk acceleration variability (preferred speed, subdued light)		Change in ML trunk acceleration variability (preferred speed, subdued light)	
	R^2	p-value	R^2	p-value	R^2	p-value
Change in preferred gait speed	0.02	0.66	0.01	0.36	<0.01	0.70
Change in visus corrected	0.00	0.89	0.00	0.92	<0.01	0.67
Change in photopic	0.00	0.89	0.01	0.36	0.01	0.46
Change in mesopic	0.04	0.05	0.01	0.49	0.03	0.11
Change in stereopsis	0.02	0.63	0.02	0.13	0.00	0.98

Bivariate linear regression analyses between change in trunk acceleration variability and change in gait speed, and change in trunk acceleration variability and change in vision, were performed to determine whether the changes in trunk acceleration variability could be explained by the changes in gait speed or vision over time. This analysis was only carried out where significant changes over time in the trunk acceleration variability were found (see Tables 1 and 2), and the results are shown in Table 8. Neither in normal nor subdued light was the change in gait speed or change in vision significantly associated with the change in trunk acceleration variability.

5. Discussion

5.1 Main findings

The purpose of this study was to assess whether trunk acceleration variability changed as a result of cataract surgery. Results suggest that there are significant differences in the changes over time between the cataract and control group in both normal and subdued lighting in preferred speed in all three directions, with a tendency for the cataract group to decrease variability, and the control group to increase variability during the 12 months of follow-up. It

seems that the change in trunk acceleration variability during gait for the cataract group cannot be explained by the change in vision or in gait speed that occurred over the follow-up period.

5.2 Trunk acceleration variability

5.2.1 Normal light

For preferred gait speed, changes in between stride-to-stride trunk acceleration variability between the cataract and the control group during the 12 months of follow-up are significant for all directions, with the cataract group decreasing their trunk acceleration variability relative to the control group. Trunk acceleration variability in both antero-posterior and vertical direction decreases as hypothesized, but in medio-lateral direction results were in the opposite direction of the hypothesis. The expectation that medio-lateral trunk acceleration variability would increase with improved vision and decrease over time was based on previous findings in a cross-sectional study where they found higher medio-lateral, but lower antero-posterior and vertical trunk variability in healthy, compared to mobility impaired, elderly (43). However, the results here could also be seen to be in support of previous findings that increased variability, both spatio-temporal and trunk, in the any of the three directions is an indication of impaired postural stability (39, 64, 65). If decreased variability in all three directions can be considered an indication of improved stability during walking, then these findings suggest that postural stability during gait improves following cataract surgery, while postural stability reduces over time among generally elderly population. From research on age-related changes on gait it is known that gait becomes increasingly more careful (29) and that this is an adaptation for controlling postural stability. However, with increasing age, the ability to control postural stability also seems to decrease (29). The tendency towards increasing variability in the control group during the year of follow up, suggests less ability to control posture during gait with aging. This means that even though the hypothesis was proven wrong in the medio-lateral direction, results may still show that cataract surgery improves trunk acceleration variability. It is an encouraging finding that cataract surgery appears to have reduced or reversed this decline in postural stability at 12 months after surgery.

A possible reason for not meeting the hypothesis in the medio-lateral direction could be that the hypothesis was based on a study which had important differences in design. Moe-Nilssen

and Helbostad (2005) carried out a cross-sectional study, not looking at change over time (43). Results in this study suggest that in the medio-lateral direction, trunk acceleration variability did not follow the theory that decreased variability was a sign of more conservative gait and reduced degrees of freedom. Rather decreased variability in all three directions is being interpreted as an improvement in gait, also because the control group has the opposite development.

In fast gait speed the pattern of significant changes between the two groups found in the preferred speed walks was not repeated. Following the arguments from preferred gait speed, one would have expected that also in fast gait speed trunk acceleration variability would decrease. Therefore, it was surprising that a significant decrease was not found here. It has previously been reported that increased gait speed will increase trunk acceleration (55), but that trunk acceleration variability in the medio-lateral and vertical direction during gait is higher in slow gait speed than in preferred and fast gait speed with young adults (54). In general, variability was lower at fast speed than at preferred speed for both groups in all conditions and at both assessment points, particularly for medio-lateral and vertical directions, which indicates that increased gait speed leads to less trunk acceleration variability also in elderly adults. However, relative improvement in stability during gait due to cataract surgery was not apparent in the fast speed walks. It is possible that the decreased gait speed from baseline to 12-month follow-up in the control group influenced the result. Differences in trunk acceleration variability between the groups might have been found if testing in slow gait speed had been tested, as slow gait speed may have been better at detecting instability than fast gait speed (54).

Gait speed was found to change significantly between the two groups from baseline to 12-month follow-up at both speeds and in both lighting conditions (Table 5). There was a tendency for the cataract group to either walk at the same gait speed or faster from baseline to 12-month follow-up, whereas the control group decreased their gait speed. This suggests that the participants who underwent cataract surgery reduced or reversed the expected aging-related slowing of gait speed over the year. Previously it has been shown that gait speed is associated with future mortality (35), and improvement in gait speed may therefore also be looked upon as an important benefit of cataract surgery.

31

5.2.2 Subdued

In subdued light during preferred gait speed, results of the between group analysis of trunk acceleration variability show a similar pattern to normal lighting condition, with a significant difference in the change over time between the two groups. The same trend was seen as in normal light, with a relative decrease of trunk variability in the cataract group compared with the control group. As in normal light, it was hypothesized that antero-posterior and vertical trunk acceleration variability would decrease relative to the controls, but medio-lateral trunk variability was hypothesized to relatively increase in the cataract group. However, just as in normal light, the cataract group showed relative decreases in trunk acceleration variability in all three directions, thereby adding support to the suggestion that decreased variability in all three directions indicates better stability during walking. There were no additional differences found because of the low lighting condition. A possible explanation for the similarities between normal and subdued light was that all participants were given 2 minutes to adapt their vision to the change in lighting condition, which may have led to gait similar to normal light. Even though gait in subdued light or in darkness has previously been shown to lead to a more careful gait (52), this effect may have been ameliorated because of the time to accommodate. In their study of modulation of gait during visual adaptation to darkness, Moe-Nilssen et al (2006) found that all variables including trunk acceleration variability showed an approximation toward values tested in normal lighting 60-90 seconds after walking in subdued light (57). With participants given 2 minutes to adapt vision before starting to walk, this is likely to have happened here as well. This was also done in a study conducted by Helbostad et al (2009), showing no effect on trunk acceleration variability in subdued light during walking compared to normal light gait (47).

As in normal light trunk acceleration variability might be considered in relation to increased gait speed. The cataract group increased their gait speed over the follow-up period. This may be an explanation for the decreased trunk acceleration variability relative to the control group. However, as will be discussed later, there appeared to be no significant association between change in gait speed and change in trunk acceleration variability.

In fast gait speed in subdued light, trunk acceleration variability in the vertical direction showed a significant difference in the change over time between the groups, with the cataract group having a small decrease and the control group an increase in trunk acceleration variability. No other significant differences in the changes were detected. This is similar to the

findings for fast gait speed in normal lighting. With regard to within group changes, there are significant changes in both vertical and medio-lateral direction in the control group, but no significant changes in the cataract group. With no significant change in the cataract group, this was the same pattern as seen for fast gait speed in normal light, and suggests that surgery does not influence trunk acceleration variability at fast gait speed as much as at preferred gait speed. However, that the cataract group did not increase their trunk acceleration variability over time as the control group did, suggests that the cataract surgery may have contributed to arresting the aging-related decline that would have been expected had they not undergone surgery. In that respect, one may argue that this suggests a relative improvement following surgery at fast speed in reduced lighting, although statistical significance in the difference between the groups was not reached.

5.3 Differences between the two groups at baseline and how they develop

Figure 6 and 7 shows the differences in trunk acceleration variability between the groups at baseline. The cataract group, in general, walked with higher trunk acceleration variability in all directions in both normal and subdued light, and in both gait speeds. Further, the cataract group walked slower than the control group in both lighting conditions and at both speeds. Naturally, the cataract group also scored worse on vision test, compared to the control group. These are all indications that the cataract group at baseline had worse mobility than the control group. Because increased trunk acceleration variability is an indication of poorer postural stability and possibly greater falls risk, and low gait speed is related to increased mortality rate (35), it also appears that the group requiring cataract surgery were at higher risk of poorer health outcomes in the future. Impaired vision seems to be connected to both gait speed and stability during gait, therefore cataract surgery could be expected to improve both conditions. Within the cataract group there was a decrease in trunk acceleration variability during preferred gait speed, and only small, non-significant changes during fast gait speed in both normal and subdued light. Within the control group, trunk acceleration variability increased during gait in both normal and subdued light. With increasing age, mobility impairment and reduced postural stability are more likely. The results from this study show changes in gait speed and postural stability during walking between the groups even over a one year follow-up period.

Figure 6 and 7 also shows the direction of change for both groups during the one year follow-up period. The two groups become more similar in terms of trunk acceleration variability. This suggests that cataract surgery improves postural stability during walking to a more expected level for their age, while the control group is assumed to follow a natural development. The figures give a clear picture that the intervention has a positive effect on postural stability.

5.4 The influence of vision and gait speed on trunk acceleration variability

Vision changed significantly in all four variables (Table 6) in the cataract group, and also between groups in visual acuity and in contrast vision in low light (mesopic). However, when running a linear regression analysis between trunk acceleration variability outcomes that changed significantly over time and in vision changes within the cataract group, no significant associations were found (Table 8). A reason for the lack of correlation between trunk acceleration variability change and vision change might be that there is not a direct relationship between improved vision and change in stability during walking. The cataract surgery may lead indirectly to improved postural stability via, for example, improved amount of walking the person was able to do over the follow-up year as a result of having better vision. In addition, the walking task itself may have been too simple to detect a strong relationship between vision improvement and stability improvement. Maybe associations would have been stronger if the walking task had been more difficult.

It is interesting that cataract surgery, which does not directly affect the motor system, led to improvements in trunk acceleration variability and therefore stability during walking in older persons. Vision helps maintain postural stability (15, 18), but other factors like physiological and biomechanical factor may influence on gait as well (29). With both groups increasing their age, and therefore possibly experiencing declines in other systems directly related to postural stability, it seems that improved vision over the follow-up period somehow enabled these other systems to improve, or at least reduced their decline. Although this needs further confirmation from future research, results here should be taken into consideration when discussing positive outcome measures from cataract surgery and to further understand the importance of vision on postural stability during gait.

Gait speed has previously been shown to improve significantly following cataract surgery (19, 32), and gait speed has been found to influence trunk acceleration variability (12, 31, 52). Therefore, it was expected that an increase in gait speed could explain change in trunk acceleration variability. However, the linear regression between change in trunk acceleration variability and change in gait speed within the cataract group showed no significant association, indicating that change in trunk acceleration variability could not be explained by the change in gait speed during the testing session (Table 8). This adds further support to the suggestion that the improvement found in trunk acceleration variability within the cataract group may be brought about secondary to other changes, such as improved mobility or increased activity, over the follow-up period that were enabled by the improvement in vision.

5.5 Methodological considerations

A large portion of the eligible participants for the control group was not included. The main reason for this was technical problems with the measuring instrument. Testing with an alternative instrument at a higher sampling frequency cause problems with using the custom made software for data analysis. Because one of the inclusion criteria was that participant had to be tested at both baseline and after 12 months, participants tested with different sampling rate had to be excluded. The problem occurred mainly for the control group. As a result, there were significant difference between the groups in gender, age, and height. This means that direct comparisons between the two groups might be biased by age, gender and height differences. As mentioned, age is linked with gait speed, and increasing age leads to slower gait speed. Further, it has been reported age-associated differences related to medio-lateral stability of center of mass, with older age leading to less postural stability (48). However, as both groups got older, one might expect similar development regarding trunk acceleration variability over time. This was not the case with significant differences between the group changes in preferred gait speed. This suggests that although there is a significant difference regarding age between the two groups, this difference does not seem to impact on the overall results. Gender differences between the two groups may also affect the result. Previously, differences have been found between men and women in trunk acceleration were women walked with less medio-lateral acceleration (46), and in trunk acceleration variability in the medio-lateral direction were women seemed to walk with less variability (47). In this study, the control group consisted of relatively more men, but still the control group had a lower trunk acceleration variability compared to the cataract group, thus not finding the gender

difference as previously reported. Because the main purpose in this study was to look at changes between the two groups before and after cataract surgery, gender was considered unlikely to influence the conclusion. Even though these differences at baseline between the two groups were not expected to influence on the result, an ANCOVA analysis with age, gender, and height as covariates, was performed to control for possible influence. No changes in significant results were found between the two groups, and no significant explanation in results came from these differences. Therefore, the results regarding comparison of change in variability over time between the groups was not altered by the inclusion of the baseline age, gender or height as covariates.

Assessment of walking on a flat surface has been used in several studies when measuring gait variability (37, 42, 43, 47, 55). However, when walking on a flat surface, vision plays a relatively small role, control the surroundings for less than 10 % of the travel time, in locomotion control (15). Because the intervention in this study was cataract surgery, a task that was more reliant on vision may have been preferable. For instance, walking over obstacles would have been a task where vision plays a more important role in controlling gait (66). Since no significant interaction between change in vision and change in trunk acceleration variability was found, one can argue that gait on a flat surface wasn`t difficult enough to detect changes in postural stability caused by vision. Previous research has shown that walking on uneven terrain leads to differences in trunk acceleration variability in both normal (67) and dark lighting (57) conditions. However, the testing on a firm level surface is relevant to daily activities, and thereby testing postural stability the participants use every day. Therefore, although results in this study may have been different and possibly showing even greater effect of surgery, results here are adaptable to activities of daily life.

Subjects were tested at both preferred and fast gait speed, and in two different lighting conditions. Because of several gait conditions, the significance level in this study was lowered to 0.0125, (0.05 divided by four) to compensate for the increased probability of making type I errors. Reporting of false positive answers is not a new phenomenon in medicine, and it has been argued to minimize the false positive rates (68). On the other side, the chance of making a type II error exists because lowering the alpha level, one may overlook actual change caused by the intervention. A significance level of 0.05 would have made minor changes to the reported results within and between the two groups in both normal and subdued light, but

these changes would mainly be in the control group and would not have altered the conclusions drawn from the findings.

There is always a chance that the equipment used for testing could provide possible errors and affect results. However, previous tests with the same accelerometer equipment for measuring variability of trunk acceleration have shown it to be both precise and accurate (58) and with a high test re-test reliability (69, 70). Vision was tested using well establish testing equipment (60-63), and all tests are still in use in clinical work. Gait speed was measured using electronic photo cells connected to a computerized timing device, to avoid human error with a stopwatch. This method has also previously been used when measuring gait speed (55, 57). In our study the same surgeon operated on all patients, thus minimizing differences in treatment regime and follow-up between patients and reducing the chance of confounders, but perhaps also reducing external validity and generalisability of the findings.

5.4 Implications for clinical work

Vision is a major contributor to motor control and postural stability, and important for activities of daily living (1-3, 7), QoL (4) and for risk of falling (5, 6). Findings here suggest that patients undergoing cataract surgery reduced their antero-posterior, vertical, and medio-lateral trunk acceleration variability over the 12-month follow-up after surgery, relative to the change over time in the control group. This is presumed to be an indication of improved postural stability during walking, and shows the importance of vision in maintaining mobility. Neither change in gait speed nor change in vision seems to explain change in trunk acceleration variability. This may indicate that the improved vision does not directly lead to improved stability during walking but that perhaps improved vision allowed more mobility in general with in turn preserved or helped to improve the postural stability. Efforts to increase mobility and general activity levels of older people both with vision impairment and following vision correction seems warranted.

5.5 Conclusion

This study has shown that trunk acceleration variability during preferred gait speed changes following cataract surgery, relative to vision-healthy control subjects. These findings are present in both normal and in subdued lighting, and shows that cataract surgery leads to improved postural stability in all three directions at preferred gait speed. In fast gait speed for

the cataract group, the trunk acceleration variability is the same, after compared to before surgery in either lighting condition. In addition, there does not seem to be a difference over time between the groups. Gait speed and vision also improves following surgery, but neither of these changes explained the changes in trunk variability in the cataract group. To our knowledge, this is the first time trunk acceleration variability has been compared before and after cataract surgery. More research to confirm these results would be justified. Further research is also needed to confirm the association between trunk acceleration variability and falls risk, with different terrain and tasks, and to further investigate the mechanism by which the surgery led to improved trunk acceleration variability outcomes.

6. Literature

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