Get a grip of grip strength in persons with hand osteoarthritis

The associations between grip strength and markers of hand osteoarthritis and general health

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Get a grip of grip strength in persons with hand osteoarthritis

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Abstract

Purpose: To examine how grip strength is associated with hand osteoarthritis (OA), psychosocial factors, lifestyle-related risk factors and comorbidities.

Methods: The associations between radiographic hand OA severity (Kellgren-Lawrence sum score) in different joint groups and grip strength of the same hand were examined in 300 persons with hand OA using linear regression analyses. The analyses were repeated using markers of self-reported pain, psychosocial factors, lifestyle-related risk factors and comorbidities as the independent variables. All analyses were performed using generalized estimating equations (GEE) with adjustment for age, sex and body mass index.

Results: Increasing radiographic severity in the thumb base was associated with lower grip strength (beta=-0.82, 95% CI -1.11, -0.52). Similarly, persons with pain in the thumb base or any metacarpophalangeal joints had lower grip strength than those without pain (beta=-2.15, 95% CI -3.15, -1.16 and beta=-1.33, 95% CI -2.09, -0.57,). Significant associations with grip strength were also found for female sex (beta=-14.8, 95% CI -18.5, -11.1), low education (beta=-2.60, 95% CI-4.32, -0.88), higher comorbidity index (beta=-0.29, 95% CI -0.49, -0.08) and higher heart rate at rest (beta=-0.11, 95% CI -0.20, -0.02).

Conclusion: Structural features and pain in the thumb base joints are strongly associated with lower grip strength, and OA studies focusing on the thumb base should include grip strength as an outcome measure. However, the patient´s general health should also be considered, as other factors such as sex, socioeconomic factors, physical fitness, and comorbidities may also affect grip strength.

Introduction

Hand osteoarthritis (OA) is a highly prevalent disease, increasing in industrialized countries due to an ageing population. It represents a considerable burden of disease of which awareness in research have increased over the last decade (1, 2). However, there is still limited knowledge of the pathogenesis of hand OA and a lack of effective treatment options for the affected patients.

The main symptoms of hand OA are pain and aching in the affected joints, stiffness, loss of mobility, decreased grip strength, aesthetic damage, and disability (2). Studies of patient perspectives on hand OA have shown that problems with gripping and reduced strength are considered important factors for hand OA patients, and grip strength is being essential for the ability to carry out the activities of daily life (3). Hence, activities requiring grip strength are included in patient-reported outcome measures assessing physical function in hand OA patients (4, 5). Measurements of grip strength are important because they give an indication of the functional integrity of the hand (6). The international organization Outcome Measures in Rheumatology (OMERACT) recommends hand strength as part of the core domains for all hand OA studies, and assessment of grip strength, or alternatively pinch strength, is the current recommended instrument to assess hand strength (2). Previous studies have shown that increasing radiographic severity of hand OA is associated with reduced grip strength. In particular there is seen a higher risk of reduced grip and pinch strength in patients with radiographic OA in the thumb, including the first carpometacarpal (CMC1) joints, and the metacarpophalangeal (MCP) joints (6). It has been suggested that the association of hand OA with function and strength measurements is largely mediated by pain (6, 7).

On the other hand, in most medical areas, grip strength is being used to define frailty, with weakness considered a key manifestation of sarcopenia. Fried *et al.* included reduced grip strength as one key element of the "frailty phenotype" together with weight loss, exhaustion, slow gait speed and low activity (8). In women with normal body mass index (BMI) of 23-26 kg/m^2, low hand grip strength is defined as grip strength of the dominant hand of 17.3 kg or below. Similar values for men with BMI 24-26 kg/m^2 is 30 kg or less. Reduced grip strength is the 2^{nd} most common frailty criteria, after exhaustion, among prefrail older persons (9).

Few previous studies have investigated the association between general health and grip strength in patients with OA. In the European Project on OA (EPOSA), a cohort of elderly subjects above 65 years, 17% of the participants had clinical hand OA and associations between several comorbidities and grip strengths were identified (10).

The Nor-Hand study is a study with hand OA patients only, aiming for a better understanding of how grip strength in individuals with hand OA is affected by both their hand OA severity defined by radiographs and self-reported joint pain as well as their general health, including factors such as comorbidities, smoking and alcohol, anxiety and depression, previous injury and physical activity.

Methods

Study population

The Nor-Hand study is a large-scale hospital-based observational cohort study, including 300 patients with hand OA between the ages of 40-70 years. The current analysis includes cross-sectional data from the baseline examination. Each of the participating patients had hand OA proven either by ultrasound or clinical examination by a rheumatologist. A more detailed description of the inclusion and exclusion criteria can be found in the published protocol (1). Amongst the exclusion criteria were the diagnosis of rheumatoid arthritis, psoriasis, psoriatic arthritis, reactive arthritis, spondylarthrosis and hemochromatosis. Patients with major comorbidities making them unable to attend the study visit were also excluded.

Grip strength

Grip strength was measured using a Jamar dynamometer. The procedure was executed with the patient sitting in a chair with his or her arm unsupported, keeping the elbow in a 90-degree angle. The dominant hand was tested first, by having the patient squeeze the dynamometer as hard as possible. The test was then repeated two times with 15 seconds rest between the assessments, before the same procedure was repeated on the non-dominant hand. The results were recorded in kilograms with one decimal precision. In our analyses we used the mean grip strength from the three measurements of each hand. For two patients grip strength was measured in one hand only, leaving 598 grip strength measurements available for analyses.

Markers of hand OA

All patients obtained bilateral frontal images (posteroanterior view) of both hands. A trained reader (IKH) evaluated the 2^{nd}-5^{th} distal interphalangeal (DIP), 1^{st}-5^{th} proximal interphalangeal (PIP), MCP, CMC1 and scaphotrapeziotrapezoidal (STT) joints using validated scoring systems, such as the Kellgren-Lawrence (KL) scale (11) and the

Verbruggen-Veys (VV) anatomical phase scoring system (12). Twenty randomly selected hand radiographs were scored twice by the same reader with a mean (SD) interval of 16 (4) days between the first and second scoring. The intra-reader reliability was excellent with weighted kappa values of 0.92 and 0.93 for the KL and VV scales, respectively.

Patients were asked to rate the intensity of their pain in each hand after measuring the grip strength. Furthermore, they completed the Numeric Rating Scale (NRS) regarding hand pain and disease activity during the past 24 hours on a 0-10 (0 being no pain/disease activity and 10 the most intense pain/disease activity) and the Australian/Canadian (AUSCAN) hand pain subscale, which consists of five questions addressing pain in rest and during activities. Each question is answered on 0-4 scales, leading to a sum score of 0-20 (5). The patients were also asked to assess the presence of pain in individual hand joints during last 24 hours and the last 6 weeks using two separate homunculi. Whereas NRS pain after testing grip strength and pain in individual hand joints were assessed in both hands separately, the assessment of NRS pain and disease activity and AUSCAN pain refers to both hands together.

Markers of general health

Each patient received an electronic case report form (eCRF) (or paper version if needed) including questions regarding demographic characteristics such as education and lifestyle characteristics including physical activity, smoking and use of alcohol. Patients also responded to questions about the use of analgesics and previous injuries of the hands/wrists. In the current analyses, education was divided into two categories ("lower than or completed secondary school" vs. "higher education at college or university"). Physical activity ("how many times they exercised for at least 30 min") was divided into "low" (1-2 times a month or less) and "regular" (1-2 times a week or more).

Alcohol consumption was examined using the Alcohol Use Disorders Identification Test-Consumption (AUDIT-C), which includes three questions about the frequency and amount of alcohol drinking. Each question has response categories on 0-4 scales, giving a total sum score of 0-12 (13, 14). All participants were divided into four categories (never smoker, previous smoker and current daily smoker and current non-daily smoker). In the analyses, we dichotomized the smoking variable into current smokers (daily and non-daily) vs never/previous smokers.

Psychological health was assessed using the Hospital Anxiety and Depression scale (HADS), (15) containing 14 questions on 0-3 scales regarding symptoms of depression and anxiety,

giving a total score of 0-42. We collected data on comorbidities by having each patient responding to The Self-Administered Comorbidity Questionnaire, which includes 12 of the most prevalent medical conditions in general practice (16). To illustrate the severity and consequences of the diseases, the questionnaire includes questions about treatment and how the conditions are affecting daily life. A trained medical student inspected the answers along with the patients, comparing the comorbidities to their list of medications (1). Regular use of analgesics was defined as self-reported regular use of oral acetaminophen, non-steroidal anti-inflammatory drugs or opioid or opioid-like analgesics.

To calculate body mass index (BMI, kg/m^2), a trained medical student measured the height and weight of the patients. Height was measured to the nearest millimeter and weight in kilograms to one decimal precision. Blood pressure and heart rate were measured by a trained medical student. The examination was done with the patients in sitting position after 5 minutes of rest in supine position in a quiet room. Repeated measurements were performed until the two measurements have a 5 mmHg or less difference in both systolic and diastolic blood pressure, and the mean of these tow measurements were used in analyses.

Statistical analyses

We calculated grip strength within different age groups in men and women. Normative values from the general population were presented for comparisons (17). The severity of radiographic OA in different joint groups (i.e. rays and rows) was calculated using KL sum scores of the respective joints (11). Erosive hand OA was defined at person level, as having at least one erosive DIP or PIP joint (i.e. in the erosive or remodeled phases) according to the VV anatomical phase scoring system (12). The association between radiographic hand OA severity (independent variable) and grip strength of the same hand (dependent variable) was examined using linear regression analyses. Unstandardized beta values with 95% confidence intervals are presented. The analyses were repeated using self-reported pain, self-reported disease activity, demographic and clinical characteristics and markers of general health as the independent variables. All analyses were performed using generalized estimating equations (GEE) to account for dependency between the two hands within each patient. All analyses were adjusted for age, sex and BMI.

Results

Demographic and clinical characteristics are shown in Table 1. The majority of the participants were women. More than half of the participants had at least one year of college or university. The participants demonstrated a wide range of radiographic severity and symptom severity, although only a minority of the participants reported regular use of analgesics. The majority fulfilled the American College of Rheumatology (ACR) criteria for hand OA. In total 70 (23.3%) and 38 (12.7%) participants had anxiety and depression scores of 7 or above on the HADS, respectively. There were few current smokers (daily: n=31 (10.3%), non-daily: n=14 (4.7%)) and high frequency of regular physical activity. On the other hand, the prevalence of possible harmful alcohol drinking was high. Persons with high education did not have statistically significantly higher AUDIT-C values than patients with low education (Mean (SD): high education 3.33 (1.66) Vs. low education 3.05 (1.68), p = 0.15). Only 38/205 (18.5%) of the persons who fulfilled the criteria of possible harmful drinking got all their points due to frequent consumption of alcohol (i.e. at least 2-3 times per week for women, and at least 4 times per week for men), but few units (i.e. only 1-2 units on a typical drinking day, and never drinking 6 units or more).

Table 1: Demographic and clinical characteristics of the study population (n=300)

Age, median (IQR)	61.0 (56.4–65.6)
Sex, n (%) women	266 (88.7)
Body mass index, mean (SD) kg/m^2	26.5 (5.0)
Low education, n (%) *	125 (41.8)
Current smoking (daily and non-daily), n (%)	45 (15.0)
High alcohol consumption (AUDIT-C), n (%) *	205 (68.6)
Previous injuries*	
Right hand/wrist, n (%)	49 (16.5)
Left hand/wrist, n (%)	49 (16.5)
Physical exercise *	
3 or more times per week, n (%)	85 (28.8)
1-2 times per week, n (%)	120 (40.7)
Not regularly or 1-2 times per month, n (%)	90 (30.5)
Systolic blood pressure, median (IQR) mmHg *	129.0 (116.5-141.5)

Diastolic blood pressure, median (IQR) mmHg *	79.0 (73.5-84.5)
Heart rate at rest, median (IQR) beats/min *	69.0 (62.0-76.0)
Self-administered comorbidity questionnaire sum score (range 0-45), median (IQR) *	16.3 (0.8-31.8)
Hospital Anxiety and Depression Scale (0-42), median (IQR) *	6.0 (3.0–10.0)
Fulfilling the ACR criteria for hand OA, n (%)	278 (92.7)
NRS pain last 24 hours (range 0-10), mean (SD) *	3.8 (2.3)
NRS disease activity last 24 hours (range 0-10), mean (SD) *	3.7 (2.2)
AUSCAN pain (range 0-20), mean (SD)	8.2 (4.0)
Regular use of oral analgesics, n (%)	44 (14.7)
KL sum score all joints left hand (range 0-64, median (IQR) *	14.0 (6.5-21.5)
KL sum score all joints right hand (range 0-64, median (IQR)	14.0 (7.0-21.0)
Erosive hand OA, n (%)	106 (35.3)

ACR=American College of Rheumatology, NRS=Numerical Rating Scale, AUSCAN=Australian/Canadian Osteoarthritis hand index, AUDIT-C=Alcohol Use Disorders Identification Test-Consumption, KL=Kellgren-Lawrence rating scale.

* 1 missing value for education, alcohol consumption, systolic blood pressure, diastolic blood pressure, NRS pain, NRS disease activity and KL sum score in the left hand. 2 missing values for heart rate at rest. 3 missing values for previous injuries. 5 missing values for physical exercise. 10 missing values for HADS.

In general, women and men from the Nor-Hand study demonstrated lower grip strength than previously observed in the general population across all age groups, especially in the right hand (dominant hand for 92.3% of the study population) (Table 2). The differences between age categories were larger in the general population than in the Nor-Hand study, where a similar decline in grip strength with increasing age was not observed. In both the general population and the Nor-Hand study, men demonstrated considerably higher grip strength than women (Table 2). In our study, 94 (35.3%) and 12 (35.3 %) of the women and men fulfilled the criteria of reduced grip strength for the Fried´s criteria of frailty (8).

Table 2: Grip strength in persons with hand OA* in comparison with normative value from the general population

	Men			Women		
Age group	Normative	Nor-Hand	P-value	Normative	Nor-Hand	P-value
45-49 years						
Right	49.8 (10.4)	41.3 (1.9)	0.26	28.2 (6.8)	20.9 (8.4)	0.005
Left	45.7 (10.3)	38.1 (3.1)	0.31	25.4 (5.7)	21.1 (5.9)	0.03
50-54 years						
Right	51.5 (8.2)	41.1 (21.5)	0.13	29.8 (5.2)	20.4 (8.8)	<0.001
Left	46.2 (7.7)	37.5 (14.3)	0.15	26.0 (4.8)	19.0 (9.4)	0.002
55-59 years						
Right	45.9 (12.1)	28.7 (10.0)	0.09	26.0 (5.7)	19.5 (7.0)	<0.001
Left	37.7 (10.6)	31.5 (6.7)	0.14	21.5 (5.3)	18.3 (6.9)	0.04
60-64 years						
Right	40.7 (9.2)	37.5 (14.5)	0.43	25.0 (4.5)	21.6 (6.3)	0.02
Left	34.8 (9.2)	33.3 (15.9)	0.73	20.7 (4.5)	19.9 (6.6)	0.58
65-69 years						
Right	41.3 (9.3)	34.5 (9.1)	0.06	21.3 (4.3)	20.1 (8.1)	0.42
Left	34.8 (8.9)	34.2 (12.2)	0.87	18.6 (3.7)	18.7 (9.1)	0.95

** one person with age of 43 years and 9 persons with ages of 70 years excluded from analyses. Normative values from Mathiowetz et al.(17).*

Women had statistically significantly lower grip strength than men, whereas weak and non-significant associations with grip strength were observed for increasing age and BMI. Low education, higher comorbidity index and increasing heart rate at rest were associated with lower grip strength. Patients with symptoms of anxiety and/or depression had lower grip strength than those with no such symptoms, but the association did not reach statistical significance. No statistical significant associations were found for current smoking, high alcohol consumption, previous injuries of the hand/wrist, blood pressure and self-reported low physical exercise. (Table 3)

Table 3: Demographic and clinical characteristics, including markers of general health, and their associations with grip strength (adjusted for age, sex and body mass index, as appropriate)

	Beta (95% CI)	p value
Age	-0.05 (-0.19, 0.09)	0.51
Sex	-14.8 (-18.5, -11.1)	<0.001
Body mass index	-0.14 (-0.35, 0.06)	0.18
Low education	-2.60 (-4.32, -0.88)	0.003
Current smoking	-1.26 (-4.52, 2.00)	0.45
High alcohol consumption (AUDIT-C)	0.59 (-1.21, 2.39)	0.52
Previous injury	-0.16 (-1.01, 0.70)	0.72
Physical exercise		
3 or more times per week	0.00 (ref.)	
1-2 times per week	-0.55 (-2.70, 1.60)	0.62
1-2 times per month or less	0.98 (-1.58, 3.53)	0.45
Systolic blood pressure	0.02 (-0.03, 0.06)	0.51
Diastolic blood pressure	-0.03 (-0.13, 0.06)	0.50
Heart rate at rest	-0.11 (-0.20, -0.02)	0.02
High self-administered comorbidity	-0.23 (-0.38, -0.07)	0.004
Hospital Anxiety and Depression Scale	-0.14 (-0.30, 0.02)	0.08

CI=confidence interval

All markers of self-reported hand pain and disease activity were strongly associated with lower grip strength (Table 4). Having one or more painful MCP or thumb base joints the last 6 weeks was associated with lower grip strength (separate models). When pain in MCP 1-5 and pain in the thumb base were included in the same model, the associations remained statistically significant for both joint groups (thumb base: beta=-1.49, 95% CI-2.51, -0.48; MCP 1-5: beta=-1.15, 95% CI-1.94, -0.35). Looking at the different rays, a statistical significant association was found for the thumb joints only. When pain in the thumb base, MCP1 and IP1 were included in the same model, we found a statistical significant association for the thumb base only (beta=-1.71 95% CI -2.83, -0.59).

Similar associations were found when using pain the previous 24 hours, with a significant association for the thumb base (beta= -2.97 95% CI -3.85, -2.08), the MCP 1-5 joints (beta= -0.98 95% CI -1.71, -0.25) and for Ray1 (beta= -0.96 95% CI -1.56, -0.36) in separate models.

Table 4: Hand pain and disease activity and their associations with grip strength (adjusted for age, sex and body mass index).

	Beta (95% CI)	P-value
NRS disease activity	-0.98 (-1.43, -0.65)	<0.001
NRS pain	-1.04 (-1.37, -0.60)	<0.001
NRS pain after grip strength	-0.88 (-1.14, -0.61)	<0.001
AUSCAN pain	-0.48 (-0.69, -0.27)	<0.001
Regular use of oral analgesics	-3.88 (-6.84, -0.89)	0.01
Painful joints previous 6 weeks		
Any painful hand joint (yes/no)	-0.37 (-0.12, -0.13)	0.002
Any painful joint in joint groups (yes/no)		
DIP 2-5	-0.29 (-0.80, 0.23)	0.28
PIP 1-5	-0.30 (-0.79, 1.20)	0.24
MCP 1-5	-1.33 (-2.09, -0.57)	0.001
Thumb base	-2.15 (-3.15, -1.16)	<0.001
Any painful joint in rays (yes/no)		
Ray 1 (Thumb base, MCP1, IP1)	-0.95 (-1,40, -0.49)	<0.001
Ray 2 (MCP2, PIP2, DIP2)	-0.21 (-0.77, 0.35)	0.46
Ray 3 (MCP3, PIP3, DIP3)	-0.62 (-1.36, 0.11)	0.1
Ray 4 (MCP4, PIP4, DIP4)	-1.20 (-2.40, -0.01)	0.05
Ray 5 (MCP5, PIP5, DIP5)	-0.66 (-1.56, 0.24)	0.15

CI= Confidence Interval, NRS=Numerical Rating Scale, AUSCAN=Australian/Canadian Osteoarthritis hand index, DIP=distal interphalangeal, PIP=proximal interphalangeal, MCP=metacarpophalangeal, IP=interphalangeal.

Increasing radiographic severity in the PIP joints and thumb base joints was associated with lower grip strength (Table 5), but the association remained statistically significant for the thumb base only, when both joint groups were included in the same model (thumb base: beta= -0.78, 95% CI -1.09, -0.48; PIP 1-5: beta= -0.11, 95% IC -0.27, 0.05). Looking at the different fingers, only OA in the thumb was statistically significantly associated with lower grip strength, whereas borderline significant associations were observed for the 3rd and 4th finger. The latter associations were weakened when ray 1, 3 and 4 were included in the same model (ray 1:beta=-0.33, 95% CI -0.58, -0.08; ray 3: beta=-0.13, 95% CI -0.51, 0.24; ray 4: beta=-0.14, 95% CI -0.52, 0.24). Within ray 1, only OA in the CMC1 joint was associated with lower grip strength (beta=-1.09, 95% CI -1.57, -0.62), whereas no significant associations were found for the STT, IP1 and MCP1 joints (data not shown).

When both radiographic hand OA severity and pain the previous 6 weeks in the CMC1 joint was included in the same model, we found that both had statistically significant association with lower grip strength (radiographic severity CMC1 joint: beta= -1.03, 95% CI -1.49, -0.56; pain last 6 weeks in CMC joint: beta= -1.54 95% CI -2.54, -0.54).

Table 5: The association between radiographic hand OA severity and grip strength in the same hand (adjusted for age, sex and body mass index)

	Beta (95% CI)	P-value
Erosive hand OA (yes/no)	-0.02 (-1.42, 1.39)	0.98
KL sum score all joints	-0.10 (-0.18, -0.02)	0.01
KL sum score in joint groups		
DIP 2-5 (range 0-16)	0.00 (-0.17, 0.17)	1.00
PIP 1-5 (range 0-20)	-0.18 (-0.34, -0.03)	0.02
MCP 1-5 (range 0-20)	0.12 (-0.26, 0.47)	0.57
CMC1/STT (range 0-8)	-0.82 (-1.11, -0.52)	<0.001
KL sum score in rays		
Ray 1 (STT, CMC1, MCP1, IP1) (range 0-16)	-0.38 (-0.62, -0.13)	0.002
Ray 2 (MCP2, PIP2, DIP2) (range 0-12)	-0.21 (-0.47, 0.05)	0.12
Ray 3 (MCP3, PIP3, DIP3) (range 0-12)	-0.29 (-0.58, 0.005)	0.05
Ray 4 (MCP4, PIP4, DIP4) (range 0-12)	-0.28 (-0.58, 0.02)	0.07
Ray 5 (MCP5, PIP5, DIP5) (range 0-12)	0.03 (-0.31, 0.38)	0.85

CI=confidence interval, OA=osteoarthritis, KL=Kellgren-Lawrence DIP=distal interphalangeal, PIP=proximal interphalangeal, MCP=metacarpophalangeal, CMC=carpometacarpal, STT= scaphotrapeziotrapezoidal, IP=interphalangeal.

Discussion

In the present study, we found that radiographic OA severity, disease activity and pain was associated with grip strength in the same hand. Pathology in the CMC1 joint was most important for the grip strength. Furthermore, other factors such as female sex, low education, a higher self-reported comorbidity score and a high heart rate at rest were also related to lower grip strength, suggesting that not only hand OA, but also the patients´general health is important for the patients´ grip strength.

In line with previous studies (18, 19), patients with hand OA tend to have a lower grip strength compared to normative values from the general population. In the population-based Framingham study, elderly subjects with symptomatic hand OA had a 10% reduced grip-strength compared to those without the disease (19). We found there to be a reduction in grip strength compared to the general population in both hands and in all the chosen age groups. In the general population, the grip strength in the dominant hand was substantially larger than in the non-dominant-hand, whereas the difference between the two hands was smaller in patients with hand OA. Our results suggest that the loss of grip strength is larger in the dominant hand despite hand OA being equally common in both hands (20). Longitudinal studies are needed to compare the loss of grip strength in the dominant hand vs. the non-dominant hand, and explore potential explanations for a higher loss in the dominant hand.

Women had statistically significantly lower grip strength than men, whereas an unexpected weak and non-significant association with lower grip strength was observed for increasing age. The difference between our study population and the general population was largest in patients below 60 years of age. No difference was found in the oldest age category (65-69 years), which is probably due to high prevalence of hand OA in these age groups in the general population (20).

In other medical areas, grip strength is mainly used as a marker of frailty. The clinical phenotype of frailty as defined by Fried, consists of five criteria. These are weakness (measured by grip strength in dominant hand adjusted for BMI), unintentional weight-loss, self-reported exhaustion, slow walking speed and low physical activity (8), and persons who fulfill 3 or more of the criteria are considered frail. In our study, 94 (35.3%) of the women and 12 (35.3%) of the men had reduced grip strength according to the definition by Fried. In Fried's original study the criterion-specific threshold for weakness was set as the lowest 20% at baseline when adjusted for gender and BMI. In the EPOSA cohort, elderly persons with clinical hand OA had more than a two-fold increased risk of frailty when adjusted for sociodemographic and health-related variables (10). The increased risk may be because of reduced grip strength due to the hand OA and/or slow walking speed, and low physical activity due to accompanying knee pain in persons with generalized OA. In the Nor-Hand study, we do not have all variables that are needed to define frailty. Hence, future longitudinal studies are needed to explore associations between frailty and OA. Hypothetically, treating OA pain may be important to avoid the development of frailty, and conversely frailty may affect the prognosis of OA.

Low education, higher comorbidity index and increasing heart rate at rest (as a potential marker of poor physical fitness) were associated with lower grip strength. Our results are in line with the EPOSA study, in which a strong link was found between functional limitation of the hand (self-reported and grip strength) and comorbidities, particularly for cognitive impairment, anxiety, depression, cardiovascular disease, peripheral artery disease and osteoporosis. In the Nor-Hand study, a borderline statistically significant association was found between anxiety/depression and grip strength, which is in line with a previous studies on patients in primary care older than 60 years (21). The observed association may be due to more comorbidities and lower physical fitness in persons with such symptoms. Our results suggest that the patient´s general health is important to take into account when evaluating the grip strength in patients with hand OA.

In this study, the most important joint affecting grip strength in patients with hand OA was the CMC1 joint. We found a statistically significant association between grip strength and both self-assessed pain and radiographic severity in the CMC joint. These results are in line with several other previous studies. A study on cross-sectional and longitudinal associations between radiographic features and measures of pain and physical function in patients with hand OA found that KL sum scores for DIP and CMC1 joints were significantly associated with AUSCAN pain and physical function, but the strongest connection to grip strength was observed for the CMC1 joint (18). Similar results were found in studies conducted by Dominic *et al.* and by Spacek *et al*., who found that that impaired grip strength played a more important role for hand disability among persons with OA in the CMC1 joints than in the MCP and PIP joints (6, 22). In our study, the association between radiographic severity in the CMC1 joint and grip strength was not fully explained by accompanying pain, suggesting that structural pathology in the joint in itself may also affect the grip strength. The OMERACT report recommends hand strength as part of the core domains for all hand OA studies (2). However, current evidence suggests that measurement of grip is most useful in studies focusing on OA in the thumb base joint.

There are a few limitations to our study. Although both men and women were included, the female predominance amongst patients with hand OA resulted in the study population consisting mostly of women. It is therefore unknown whether the results in this study can be extrapolated to men. There is also a limited generalizability as most patients with OA are managed in primary care, while this study had a hospital-based design with patients from secondary care.

In conclusion, our study found that pathology in the CMC1is the most important factor to influence grip strength in patients with hand OA, and clinical trials focusing on the thumb base joints should include grip strength as an outcome measure. However, other factors than joint-related pathology such as female sex, socioeconomic factors (i.e. low education), physical fitness (i.e. a high resting heart rate) and comorbidities might also affect grip strength, and the patient´s general health is therefore important to consider when evaluating the grip strength in patients with hand OA.

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Behind the study; get a grip of grip-strength in persons with hand osteoarthritis.

The associations between grip strength and markers of hand osteoarthritis and general health.

1.1 Precept

These pages are intended as a summary and further discussion of the work in the article/manuscript “Get a grip on grip-strength in persons with hand osteoarthritis”, which is a study conducted using data from the baseline of the Nor-Hand study at Diakonhjemmet Hospital (Oslo, Norway). Hand OA is a debilitating condition with a growing disease burden both individually on the affected patients and on the society.

1.2 Summary

Through this project I aimed to obtain a better knowledge of how grip strength is affected in patients with hand osteoarthritis (OA), and how grip strength in these patients is associated with general health, i.e. psychosocial factors, lifestyle-related risk factors and comorbidities. This study have included 300 persons with hand OA, using data from the baseline of the Nor-Hand study, which provided hand grip strength measurements for 598 hands. The associations between the two variables were examined using linear regression analyses, using hand OA severity in the different hand joints as the independent variable, and the average grip strength of the same hand as the dependent variable. The analyses were then repeated using markers of self-reported physical function and pain, lifestyle-related risk factors, psychosocial factors and self-reported comorbidities as independent variables, thus finding the association of each factor with hand grip strength. The analyses were performed using generalized estimating equations in SPSS, and all analyses were adjusted for age, sex and body mass index (BMI). Through these analyses we found a strong association between hand grip strength and all markers of self-reported pain and disease activity, as well as with low education, comorbidity and a high resting heart rate. There was no significant association with age or BMI. On joint level we found a strong association between grip strength and radiographic OA severity in the thumb base joints, as well as with self-reported pain the last 6 weeks in the thumb base joints. The results suggest that the OA in the thumb base joint has most impact on grip strength in patients with hand OA . Hence, future studies of hand OA in the thumb base joints should include grip strength as an outcome measure. Our findings also showed that grip strength in patients with hand OA is affected by other factors such as female sex, physical fitness,

comorbidities and socioeconomic factors. Thereby our results indicate that the patients´ general health should be considered when examining grip strength in persons with OA of the hands.

1.3 Introduction

OA is considered one of the world's most disabling joint disorders (1). It is a problem particularly in industrialized countries, where the prevalence of OA is expected to increase further in the future due to an ageing population and higher obesity rates (2). In 2008, it was estimated that nearly 27 millions of American adults had OA, increasing from the estimated 21 million in 1995 (3). OA can appear in any synovial joint in the body, but it is most prevalent in weight-bearing joints; commonly affecting the knee, hip and hand joints. A range of stressors, risk factors and genetics are of significance when it comes to determining whether an individual will develop OA in a particular joint. For that reason, research into all the joints commonly affected by OA is crucial for understanding the disease (4). To the current date there exists no disease-modifying treatment for OA. For my project I have chosen the subject of hand OA and its association to grip strength, and the association between grip strength and general health. Hand OA is considered a severely debilitating condition with high social and economic costs (5). It causes pain, fatigue and functional limitations, but despite this, limited research has been performed on the subject. Fortunately, the increase in prevalence has led to a similarly increasing interest among researchers and practitioners, but there is still much to be discovered regarding the pathogenesis of OA.

Among what we already know of OA is that it is a condition affecting the whole joint, with symptoms arising not only from the articular cartilage and the underlying bone, but also muscles, synovium, tendons and ligaments (6, 7). This makes OA a condition with a complex range of symptoms. The main symptoms of hand OA are pain and stiffness in the affected joints, disability, esthetic damage due to bony deformities and enlargements, as well as decreased mobility and grip strength (8). Additionally, inflammation of the joint can generate warmth, effusion, redness and/or soft tissue swelling. Hand OA is a heterogenous disease often involving multiple joints (5). Usually it is divided into subgroups depending on the joints affected; These groups are OA of the first carpometacarpal (CMC1) joint, nodal OA and erosive OA (7). OA of the CMC1 joint have been recorded as the most prevalent, and the subtype that most frequently occurs alone. It is followed in frequency by nodal OA of the interphalangeal joint, non-nodal interphalangeal OA and erosive hand OA, which are known to overlap (9).

Hand OA is a highly prevalent condition (2, 8). The estimated prevalence depends, however on the age, gender and the geographical area of the studied population, as the condition varies greatly (7). It also depends on the chosen definition of hand OA. Hand OA can be defined clinically by the American college of Rheumatology hand OA criteria (10), or by radiography using e.g. the Kellgren Lawrence scale (11), or thirdly by considering symptomatic and radiographic signs combined. Radiographic hand OA is associated with the highest prevalence, while symptomatic hand OA is lower (7). In our study we have included both self-assessed pain and disease-activity focusing on typical symptoms and function, and radiographic severity.

Previous studies have shown that increasing radiographic severity of hand OA is associated with reduced grip strength. In particular. a higher risk of reduced grip and pinch strength in patients with radiographic OA in the thumb, including the CMC1 joints, and the metacarpophalangeal (MCP) joints has been detected (12). However, several previous studies on the subject have suggested that hand OA's association to function and strength measurements is in fact largely mediated by pain (12, 13). This issue was one of the connections I aimed to investigate further in my analyses. According to The international organization Outcome Measures in Rheumatology (OMERACT), grip strength is one of the most frequently used method to assess hand function, as part of the core domains for all hand OA studies (8). There are several reasons for this; Hand grip strength measurement is a simple way to assess the functional integrity of the hand (12), it is a non-invasive instrument and well suited for clinical use. It has become a preferred alternative in performance-based measurement of clinical function not only in studies of hand OA; For instance it is increasingly used to predict short and long-term mortality, and also frailty and prefrailty in elderly individuals (11, 13). Impaired grip strength have also proved to be useful as an indicator of increased postoperative complications, length of hospitalization and a higher rehospitalization rate in inpatients (14). According to epidemiological studies, grip strength is also a useful predictor of cardiovascular diseases (15) and all-cause mortality in healthy adults, as well as for predicting increased risk of functional limitations later in life (14). In the elderly population, the loss of grip strength implies loss of independence (14), and it is strongly connected to frailty. The clinical phenotype of frailty as suggested by Fried, is defined by five criteria; weakness, unintentional weight-loss, self-reported exhaustion, slow walking speed and low physical activity (16). Subjects who exhibit 3 or more of the criteria are considered frail, while scoring positive on one or two of the criteria categorizes you as pre-frail. Weakness is the most common first manifestation of clinical frailty (16), and grip strength measurements can thus help detect early signs of, and prevent, frailty.

Patients with hand OA frequently report difficulty and frustration in performing everyday activities due to the pain and functional limitations associated with the disease (7). Further research on hand OA can help to provide improved management of OA; Treatment that is better adjusted to the individual patient's condition, and that ultimately can give the patients a better quality of life. As mentioned above, OA is particularly prevalent among the elderly. Hence identifying prefrailty and frailty in OA patients should also be considered important, as the measurement of grip strength play an important role in this process as well. Despite the different uses of grip strength in scientific studies, and the increasing interest in further understanding the mechanisms of hand OA, no previous study to our knowledge have focused on the association between grip strength and markers of hand OA and general health. We therefore believe that this is a subject worth investigating further.

1.4 Method

The analyses performed in the making of "Get a grip of grip strength in patients with hand OA" are based on cross-sectional data from the baseline examination of the Nor-Hand Study; a large scale hospital-based observational cohort study including 300 patients aged between 40-70 years. Hand OA was proved in each participant, either by the use of ultrasound or by clinical examination performed by a seasoned rheumatologist. The clinical examination criteria for hand OA are the presence Heberden or Bouchards nodes and/or bony enlargement, squaring and/or deformity of the thumb base, combined with absence of all clinical signs of inflammatory arthritis (defined as soft tissue swelling of two or less metacarpophalangeal joints, and no soft tissue swelling at the wrist). The ultrasound criteria for hand OA were osteophytes in the interphalangeal joints and/or the thumb base, and no signs of inflammatory arthritis (2). Patients were excluded if they had a diagnosis of inflammatory arthritic disease (for instance rheumatoid arthritis, psoriatic arthritis, spondylarthrosis and reactive arthritis), a diagnosis of psoriasis, hemochromatosis, or major comorbidities making them unable to attend the study. Accordingly, all patients included in the Nor-Hand-study were thoroughly screened both for elevated inflammatory markers, rheumatoid factor and cyclic citrullinated peptide antibodies. Because of this thorough screening process, The NorHand study is believed to consist exclusively of patients with primary hand OA. A more descriptive list of the inclusion and exclusion criteria can be found in the published study protocol (2). Patients with both early and severe OA were included in the study, providing a wide range of symptoms. However, we know that most patients with hand OA are managed in primary care.

This means that the hospital-based design of the NorHand study will limit the generalizability of our findings.

Grip strength was measured using a Jamar dynamometer. There is a wide variability in choice of protocol and equipment for measuring hand grip strength (17), making it difficult to compare results between studies. However, the Jamar Dynamometer is the one most widely cited in literature, and even described as the "gold standard" used to evaluate other dynamometers (17). There has been reported a higher grip strength for patients sitting with the elbow in a 90 degrees flexed position rather than with the arm fully extended (18). Also, it has been found that grip strength gradually decrease during repeated measurements, while measurements taken at 1 min intervals provide a constant value (19). This indicates that using the Jamar dynamometer, having the patients sit with a 90 degree flexion in the elbow and using three repeated measurements with 15 sec intervals were all good choices for our study, providing a representation of the patients highest possible hand grip strength. Possibly our study should have had a longer interval of rest between grip strength measurements.

As described more thoroughly in the article, bilateral frontal radiographic images of both hands were obtained from each patient. Conventional radiography is the method most frequently used to assess structural damage in hand OA (8). It is considered cheap, easily reproducible and widely available, and allows visualization of the signs of structural damage; joint space narrowing, osteophytes, sclerosis, subchondral cysts and central erosions (8). The radiographic images were evaluated using validated scoring systems, such as the Kellgren-Lawrence (KL) scale (11) and the Verbruggen-Veys (VV) anatomical phase scoring system (20). According to a report from the OMERACT Hand Osteoarthritis special interest group (8), studies have shown that both the KL standardized scoring system and the VV anatomical phase score are reliable instruments for assessing structural damage in patients with hand OA (21). Self-reported pain and disease activity were assessed using Numeric Rating Scale, and the Australian/ Canadian (AUSCAN) hand pain subscale; which is a hand OA-specific patient-reported outcome measure addressing joint pain, stiffness and difficulties with chosen daily activities (22), and therefore is frequently used in studies of hand OA.

Information regarding the demographic characteristics of our patient population was obtained by use of an electronic case report form, including questions about factors such as education, physical activity, smoking and alcohol consumption. Alcohol consumption was examined using the Alcohol Use Disorders Identification Test-Consumption (AUDIT-C). For the study analyses we decided to set a cut-off of 3 or more for women and a cut-off of 4 to identify hazardous or harmful drinking, as this have been recommended by several previous studies

(23, 24). The Hospital Anxiety and Depression scale (HADS) (25), were used to assess the psychological distress of the patients in the Nor-Hand study. To assess comorbidities each patient responded to The Self-administered Comorbidity Questionnaire (26), a highly reproducible method for assessing comorbidity for clinical and health services research. It consists of questions regarding 12 selected medical conditions frequently seen in general practice, and questions about possible treatment and disease burden.

Using linear regression analyses in SPSS, the association between hand OA severity (independent variable) and grip strength in the same hand (dependent variable) were investigated. The results of these analyses are presented in the article in the form of unstandardized beta values with 95% confidence intervals. The analyses were repeated for self-reported pain, self-reported disease activity, demographic and clinical characteristics and markers of general health. All analyses were performed using generalized estimating equations (GEE) to account for dependency between the two hands within each patient, and all the analyses were adjusted for age, sex and BMI.

1.5 Results

Firstly, we focused on obtaining an overview of the demographic and clinical characteristics of the study population. The majority of the participants in the study were women, which is most likely due to the fact that OA is more prevalent in women than in men, and therefore that more women than men are apt to be referred to secondary care for hand OA. The participants demonstrated a variety in severity of both radiographic and symptomatic OA, but the majority fulfilled the American College of Rheumatology (ACR) criteria for hand OA. Symptoms of anxiety and depression were found to be relatively common. We also saw a high prevalence of possibly harmful alcohol consumption, which we then found not to have a statistically significant association to low education level. The grip strength measurements of the hand OA patients in the Nor-Hand study were compared with normative values from the general population (Normative values from Mathiowetz et al.(27)). As expected we observed lower grip strength for the men and women in the Nor-Hand study compared to the general population across all age groups. While the normative values showed a decline in grip strength with increasing age, the differences between age categories were more subtle for the patients in the Nor-Hand study, and this was reflected in the lack of significant association between lower grip strength and increasing age.

As mentioned in the introduction, there is an increasing interest in the use of grip strength as an indicator of frailty. We therefore found it relevant to conduct analyses in order to see how many of the Nor-Hand patients who can be considered frail according to the criteria of reduced grip strength included in Fried's criteria of frailty (16). This turned out to be 35.3% of the women and 35.3% of the men.

In despite of what one might expect, we found no significant connection in our population between lower grip strength and BMI or age, nor for self-reported low physical exercise, current smoking, high AUDIT-C score, previous injuries of hand/wrist or blood pressure.

As stated in the article, we found all markers of self-reported hand pain and hand disease activity (such as the Australian/Canadian OA hand index for pain, and the Numerical Rating Scale scores for disease activity, pain, and pain after grip strength testing) to be strongly associated with lower grip strength. Concerning self-assessed pain in hand joints the last 6 weeks, we found an association between low grip strength and pain both in the thumb base and the MCP joints. However, when the two joint groups were included in the same model, there proved to remain a statistical association for the thumb base joint only. Similar associations were found for self-assessed joint pain the last 24 hours. Increasing radiographic severity in proximal interphalangeal (PIP) joints and thumb base were both associated with lower grip strength, but the association with the PIP joints weakened to not significant when the two were included in the same model, while the thumb base joint remained significant. When both pain the last 6 weeks and radiographic severity in the CMC1 joint was included in the same model, results showed that both of the factors had a statistically significant association with lower grip strength.

1.6 Discussion

In the work on "Get a grip of grip strength in persons with hand OA", I have analyzed several factors believed to represent general health and disease burden and their associations with lower grip strength. The objective was to gain a better understanding of which factors had the strongest influence on grip strength measurements in patients with hand OA. To our knowledge this is the first study performed on this particular subject. In the study we found first and foremost that radiographic OA severity, disease activity and pain was associated with grip strength in the same hand. Furthermore, OA in the CMC1 joint proved to have the greatest impact on the outcome of grip strength. There was also a significant association between lower grip strength and other factors, such as female gender, education lower than/or completed secondary school, a high heart rate at rest (as a potential marker for low physical

fitness) and a higher self-reported comorbidity score. This indicates that grip strength in our patients is affected not only by hand OA and OA severity, but the patients´ general health as well.

Several studies have been conducted on the relations between hand OA and comorbidity and lifestyle-related risk factors such as alcohol, smoking and BMI, considering that a large part of OA patients are elderly, and the occurrence of comorbidities in patients with hand OA is relatively high (28). In our study we found that a higher comorbidity index was strongly associated with lower grip strength. Our results are in line with the European Project on OsteoArthrosis (EPOSA) cohort; a study of elderly Europeans with OA, in which there was a strong link between functional limitation of the hand (self-reported and grip strength) and comorbidities, particularly for cognitive impairment, anxiety, depression, cardiovascular disease, peripheral artery disease and osteoporosis (29). This indicates that comorbidities have an important impact on grip strength in persons with OA.

In the NorHand study, we found a borderline significant association between lower grip strength and a higher HADS score, indicating a higher level of depression and anxiety in patients with lower grip strength. This is in accordance with previous studies on patients in primary care older than 60 years (30), and possibly this association is due to higher prevalence of comorbidities and lower physical fitness in persons with these particular symptoms.

In terms of lifestyle-related risk factors we also looked at the association between grip strength and current smoking. We know that smoking have a negative effect on cartilage and that it can induce generalized inflammation (31), but contrary to what one might expect, some clinical studies have suggested a decreased risk of OA in smokers. However, this relation have been reported primarily in hospital-based case-control studies, while no association have been found in community-based studies (31, 32). This suggests that the association may be due to selection bias, which is logical considering that smoking is a strong risk factor for diseases requiring hospitalization, such as cardiovascular and chronic obstructive lung diseases (31, 32). Studies show that both smoking and low grip strength is associated with a decline in bone mineral density (33) and that current smokers are more likely to develop frailty over a 4 year period compared to non-smokers (34), which is why we believed that investigating the association between current smoking and grip strength could provide results of interest to this study. However, in our study we found no significant association between grip strength and current smoking.

Several studies have suggested that obesity is a risk factor for hand OA, as well as for load-bearing joints (35, 36). As the mechanical effect of obesity on load bearing joints such as hip

and knees do not apply to finger joints, it have been suggested that the associations between obesity and hand OA instead could be related to systemic effects of obesity (37). However, several previous Norwegian studies have found there to be no association between overweight and hand OA for either cross-sectional or longitudinal studies (31, 38, 39). There is known to be an association between low BMI (lower muscle mass) and lower grip strength (14), but in the current study we saw no statistical connection between BMI and grip strength.
Low education and an increasing heart rate at rest were also associated with lower grip strength, while no association was found for high level of alcohol-consummation or previous injuries of the hands or wrists.

As expected, the patients in the Nor-Hand study had lower grip strength compared to the normative values from Mathiowetz et al (27). This is in accordance with previous studies on hand OA such as the Framingham study; a population-based study where elderly individuals with symptomatic hand OA were found to have a 10% lower grip strength than the subjects without OA (40, 41). The largest difference between the general population and our study population were found in patients younger than 60 years of age. For the age groups older than this, the difference between the two populations became smaller, possibly due to the fact that there is a high prevalence of hand OA in these age groups in the general population as well. As stated in the results, we found that the women of the study had a statistically lower grip strength than men. However, there were found to be a surprisingly weak connection between decreasing grip strength and increasing age, suggesting that patients with hand OA have a relatively low but stable grip strength with increasing age.

As mentioned briefly in the introduction, grip strength is frequently used not only in hand OA studies, but also in many other medical areas. Mainly it is used as a marker of frailty. According to our analyses, 94 (35.3%) of the women and 12 (35.3%) of the men in the NorHand study had reduced grip strength according to the criteria “weakness” of Fried´s definition of frailty. The EPOSA study found that elderly persons with clinical hand OA had more than a two-fold increased risk of frailty when adjusted for sociodemographic and health-related variables (29). We believe that this increased risk may be due to reduced grip strength because of the hand OA and/or slow walking speed, and low physical activity due to accompanying knee pain in persons with generalized OA. However, the Nor-Hand study did not provide the all variables that are needed to define frailty. Consequently there is a need for future longitudinal studies to further explore the associations between frailty and OA, but for

now our study suggests that treating OA pain may be important in order to avoid the development of frailty, and conversely that frailty may affect the prognosis of OA.

As stated in the article, the CMC1 joint was concluded to be the most important joint affecting hand grip strength in patients with hand OA, as there was found a statistically significant association between grip strength and both self-assessed pain and radiographic severity in the CMC1 joint. A previous study on cross-sectional and longitudinal associations between radiographic features and measures of pain and physical function in patients with hand OA found that KL sum scores for DIP and CMC1 joints were significantly associated with AUSCAN pain and physical function, but the strongest connection to grip strength was observed for the CMC1 joint (40). In studies conducted by Dominic *et al.* and by Spacek *et al*. similar results were found ; i.e. impaired grip strength played a more important role for hand disability among persons with OA in the CMC1 joints than in the MCP and PIP joints (12, 42). As mentioned in the introduction, some previous studies have stated that the association between hand OA imaging features and markers of function and strength measurements is in fact largely mediated by pain (12, 13). In our study however, the association between radiographic severity in the CMC1 joint and grip strength proved not to be fully explained by accompanying pain. This suggests that structural pathology in the joint in itself may also affect the grip strength. The OMERACT report recommends hand strength as part of the core domains for all hand OA studies (8). However, current evidence suggests that measurement of grip is most useful in studies focusing on OA in the thumb base joint.

As mentioned our study have some limitations. Hand OA is a highly prevalent condition, with a widely asserted female preponderance. This is particularly notable in patients with severe symptomatic disease presenting to secondary care, and as the population of the Nor-Hand study have been recruited from secondary care, the majority of our patients are consequently female. Furthermore, the hospital-based study-design of the Nor-Hand study represents a limitation, as most OA patients are managed in primary care. This means that the results from this study cannot easily be extrapolated to the general population.

As previously stated, it is known that patients with hand OA due to pain and functional limitations, frequently report difficulty and frustration in performing everyday activities (7). In order to provide improved management for OA patients, there is a need for treatments that are better adjusted to the individual patient's condition. As mentioned above, OA is particularly prevalent among the elderly, which is a group with a high rate of comorbidities and lifestyle-associated risk factors. Hence, the findings of this study could be of importance

for the evaluation of grip strength in patients with hand OA. For instance our study found that pathology of the CMC1 can be considered the most important joint to influence grip strength in patients with hand OA, and therefore that clinical trials focusing on the thumb base joints should include grip strength as an outcome measure. Furthermore, we found that not only joint-related pathology, but also socioeconomic factors, physical fitness and comorbidities could influence grip strength in persons with hand OA. Therefore we argue that the patients general health should be considered when evaluating grip strength in patients with hand OA. Hopefully the results of this study can be used to further discover the complex connections of factors that influence hand OA and grip strength, and thus help a large group of patients with a severely debilitating condition.

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Oslo, 30. Januar 2019

BEKREFTELSE FRA VEILEDER

Undertegnede har vært veileder for Janni Aaserud i arbeidet med artikkelen

"Get a grip on grip strength in hand osteoarthritis"

som del av hennes prosjektoppgave.

Janni har arbeidet særdeles selvstendig og flittig med artikkelen og hun har deltatt i samtlige faser av arbeidet med denne artikkelen. Hun vil derfor være førsteforfatter på dette arbeidet. Janni har hatt hovedansvar for å utføre de statistiske analysene ved hjelp av statistikk-programmet SPSS og har tolket resultatene med veiledning fra undertegnede ved behov. Videre har hun satt seg inn i relevant bakgrunnslitteratur, inkludert litteratur som ble fremskaffet av undertegnede i tillegg til litteratur som hun fremskaffet selv på eget initiativ. Hun har hatt hovedansvar for å utforme artikkelen, og har tolket våre resultater i lys av relevant bakgrunnslitteratur og tidligere studier.

Med vennlig hilsen

Ida K. Haugen

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