UMEÅ UNIVERSITY

COPD MANAGEMENT

Exploring conditions for, and experiences of, evidence-based care and eHealth

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Till min familj, blodsband eller ej,
ni är mina rötter, min stam och mitt lövverk

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Abstract

Background
Chronic obstructive pulmonary disease (COPD) is one of the leading causes of morbidity and premature death worldwide. It is a systemic disease that affects the whole person, although dyspnea is the most prominent symptom. COPD is expected to increase in prevalence during the coming 40 years due to an increase in relevant risk behaviors, and today over 230 million people suffer from COPD worldwide. A common extrapulmonary manifestation of the disease is quadriceps dysfunction, where muscle strength, power, and/or endurance properties are reduced and affect everyday function. However, reference values and valid reference equations are needed to evaluate and offer appropriate treatment for quadriceps dysfunction. Moreover, a crucial part of COPD management is pulmonary rehabilitation, e.g., where disease management and strategies are conveyed and put into practice. However, due to knowledge gaps within health care, we need to develop new ways of informing and supporting people with COPD. One way is through eHealth, although these sources must be evaluated so that they constructively contribute to health care.

Aim
The overall aim of this thesis is to explore the conditions for, and perspectives on, evidence-based care and eHealth in COPD management. This aim is twofold. The first is to explore the experiences, interactions, and context of using eHealth tools in managing COPD in primary care from the perspective of people with COPD and health care professionals (HCPs). The second is to develop reference values and equations for quadriceps function.

Method
This dissertation contains three papers (**Papers I**, **II,** and **III**) based on individual interviews analyzed with qualitative research methods in which an eHealth tool, the COPD Web, is evaluated. Lastly, it contains one paper (**Paper IV**) based on an international multicenter data collection analyzed with quantitative research methods.

Results
Paper I: The findings indicate that the level of motivation, comfortability with IT tools, and health literacy seem to affect the usage of an eHealth tool over time. Some level of use and the passage of time appears to be needed to perceive gained benefits from the eHealth tool. In short, this

suggests that eHealth tools such as the COPD Web can be suitable for supporting COPD-specific self-management skills. **Paper II:** The findings indicated that using the COPD Web provided knowledge support for HCPs and improved the quality of care for people with COPD. However, it seems some barriers need to be addressed to successfully implement the eHealth tool in daily practice. **Paper III:** Findings lead to the theme "*Perceiving enough control to enable action*", which suggests that having or perceiving a certain amount of control is essential to maintain or increase the level of physical activity when one has COPD and uses an eHealth tool. **Paper IV:** The findings indicate that for people without COPD, age, sex, height, and BMI explained 50 – 70 % of the variance of quadriceps strength, endurance, and power. Our findings also suggested moderate construct validity of the reference equations in people with COPD.

Conclusion

To conclude, the web-based eHealth tool, the COPD Web, seems to support and help when self-managing COPD and treating people with COPD. There are still barriers for people with COPD to use a web-based eHealth tool, and we probably ought to screen people with COPD for health literacy before discussing and deciding on PR strategies with them. There are still barriers to implementing new tools in the health care setting, which should need time, support, and education to circumvent. Findings regarding the developed reference values and equations for quadriceps strength, power, and endurance will make further tailoring of the treatment regime for the individual possible. As such, this, too, should assist in improving disease management, although the construct validity of the equations was moderate.

Enkel sammanfattning på svenska

Bakgrund
Kroniskt obstruktiv lungsjukdom (KOL) är en av de vanligaste sjukdoms- och dödsorsakerna i världen. Det är en sjukdom som påverkar hela individen, inte bara lungorna, där andfåddhet är det vanligaste symptomet. Under de kommande 40 åren väntas andelen personer som diagnosticeras med KOL att öka eftersom relevanta riskbeteenden blir vanligare hos befolkningen.

En vanlig följd av KOL är en nedsatt styrka, explosivitet (power) och/eller uthållighet i skelettmuskulatur, specifikt quadriceps (lårmuskel), som leder till dysfunktion vid vardagsaktiviteter. För att utvärdera funktionen, samt erbjuda relevant behandling, behövs referensvärden och validerade referensekvationer. Vidare är en av de viktigaste delarna av behandling vid KOL lungrehabilitering, där personer med KOL exempelvis får lära sig hur man kan hantera symptom och ta hand om sig själv på ett bra sätt i relation till sjukdomen. Tyvärr finns kunskapsglapp inom sjukvården vilket innebär att vi behöver hitta nya informationsvägar gällande KOL-specifik kunskap och stöttning åt personer med KOL. Ett av alternativen för kunskapsspridningen är genom eHälsa, vilket fortsatt behöver utvärderas för att säkra att de tillför konstruktiv och användbar hjälp inom vården och hos personer med KOL.

Syfte
Det övergripande syftet i avhandlingen är att utforska förutsättningar för och perspektiv på evidensbaserad vård och eHälsa kopplat till behandling av KOL. Syftet är dubbelt. Å ena sidan till att utforska erfarenheter, interaktion och kontext kring behandling av KOL i primärvården utifrån personer med KOLs respektive hälso- och sjukvårdspersonals perspektiv. Å andra sidan syftar avhandlingen till att utveckla referensvärden och referensekvationer för lårmuskelfunktion.

Metod
Avhandlingen innehåller tre intervjustudier (**Paper I, II** och **III**) utförda med kvalitativa forskningsmetoder som utvärderat ett eHälsoverktyg, KOLwebben, och en internationell multicenterstudie (**Paper IV**) som analyserats med kvantitativ forskningsmetod.

Resultat
I de tre intervjustudierna fann vi att det webbaserade eHälsoverktyget, KOLwebben, tycks vara en källa till vidareutbildning och förbättrade

behandlingsmöjligheter för både vårdhälsopersonal och personer som har KOL. Bland båda grupper sågs olika facilitatorer och hinder, tex behövs ett visst mått av hälsolitteracitet, känsla av kontroll, trygghet kring IT-verktyg och motivation för att personer med KOL ska använda verktyget och märka av förbättring i sitt tillstånd. Hos vårdpersonal behövdes en förankring av den nya arbetsmetoden inom arbetsplatsen eller vårdapparaten för att genomgå en lyckad implementeringsprocess och märka av en förbättring i vården av personer med KOL. För båda grupper gällde att tid var en viktig ingrediens, man behövde tid för att sätta sig in, förstå och implementera nya lärdomar i övriga livet. I den fjärde studien utvecklade vi referensvärden och referensekvationer för styrka, explosivitet (power) och uthållighet i lårmuskulaturen. Resultaten indikerade att för personer utan KOL förklarade ålder, kön, längd och BMI 50 – 70 % av variansen för lårmuskelstyrka, -uthållighet och -explosivitet (power). Utvecklade referensekvationer visade på måttlig begreppsvaliditet bland personer med KOL.

Slutsatser

Det webbaserade eHälsoverktyget, KOLwebben, uppfattas som ett stöd och hjälp när det gäller såväl egenvård som vård av KOL. Det finns dock hinder för att personer med KOL ska kunna använda ett webbaserat eHälsoverktyg såsom KOLwebben och fynden från denna avhandling indikerar att screening av personer med KOL gällande hälsolitteracitet bör övervägas för att kunna erbjuda lämplig lungrehabilitering (digital eller ej). Det finns även hinder för användning av eHälsoverktyg såsom KOLwebben inom vården, där mer tid, stöttning och utbildning tycks krävas för att komma vidare. De utvecklade referensvärderna och referensekvationerna för lårmuskelstyrka, -explosivitet (power) och -uthållighet kommer att möjliggöra ännu bättre personcentrerad vård, vilket i sig kommer att ge en bättre KOL-specifik behandling med måttlig begreppsvaliditetet.

Acronyms

1STS	One minute Sit-to-Stand test
6MWD	Six-minute walk distance
BMI	Body mass index
COPD	Chronic obstructive pulmonary disease
COREQ	Consolidated criteria for reporting qualitative research
eHealth	Electronic health
FEV_1	Forced expiratory volume in 1 second
GOLD	Global initiative for chronic obstructive lung disease
HCP	Health care professional
LLN	Lower limit of normal (5^{th} percentile)
MVC	Maximal voluntary contraction
RCT	Randomized control trial

Definitions

Accelerometer	Wearable instrument that measures the user's motions, e.g., step count, sedentary time, etc.
Agency	The ability to take action or to choose what action to take.
Construct validity	The extent to which your test or measure accurately assesses what it is supposed to assess.
Computerized dynamometer	A multi-mode computerized robotic measuring instrument designed to measure muscle function /muscle properties such as strength, endurance, and power.
eHealth literacy	The ability to seek, find and understand digital health information.
Health literacy	The ability to obtain, process, understand, and use healthcare information to make pertinent health decisions.
Isokinetic	During isokinetic testing, the muscle contracts at constant speeds, regardless of how much effort is exerted.
Isometric	During isometric testing, the muscle does not notably change length, and the affected joint does not move.
Isotonic	During isotonic testing, the muscle contracts against a constant weight.
Muscle dysfunction	Refers to structural and morphological abnormalities, which at the functional level is evident by impaired muscle function, i.e., reduction in muscle properties such as strength, endurance, and power.

Person-centered care	A concept and practice within health care, in which the patient is actively involved in their own treatment (in active collaboration with health professionals).
Physical activity	Any bodily movement produced by skeletal muscles that require energy expenditure.
Physical exercise	An activity that is planned, repeated, and progressed to increase the body's physical functions.
Self-efficacy	An individual's confidence in their ability to execute a behavior.
Self-management	Management by oneself of, for example, a treatment or an exercise program.
Triangulation	There are several types of triangulation, and we have used investigator triangulation. Several investigators look at the same (raw) material and then discuss their interpretations. In our case, to find an interpretative consensus.

Original papers

The thesis is based on the following papers, which will be referred to in the text by their Roman numerals:

I. Experiences and factors affecting usage of an eHealth tool for self-management among persons with chronic obstructive pulmonary disease – a qualitative content analysis. **Marklund S**, Tistad M, Lundell S, Östrand L, Sörlin A, Boström C, Wadell K, Nyberg A. J Med Internet Res 2021;23(4): e25672

II. Experiences of using an electronic health tool among healthcare professionals involved in Chronic Obstructive Pulmonary Disease management - a qualitative analysis. Nyberg A, Sondell A, Lundell S, **Marklund S**, Tistad M, Wadell K. Manuscript

III. To act, or not to act – a sense of control is important for people with COPD to increase physical activity. A Grounded Theory study. **Marklund S**, Sörlin A, Stenlund T, Wadell K, Nyberg A. JMIR Form Res 2023;7:e39969

IV. Reference equations for quadriceps strength, endurance, and power: a multicenter study. Tanguay S, Saey D, **Marklund S**, Nyberg A, Gephine S, Frykholm E, De Brandt J, Burtin C, Maltais F. Manuscript

My contributions

Short description of my role in the different papers:

Paper I: using the existing transcripts and interview recordings, I was responsible for the analysis of the qualitative data in collaboration with the co-authors. I was also responsible for writing the manuscript. **First author**, **corresponding author.**

Paper II: I was actively involved in all stages of the qualitative analysis and supported the writing of the manuscript related to methods, analysis, results, and discussion**. Co-author**.

Paper III: I was actively involved in all stages, from planning to finishing the qualitative part of the study, including the idea, data collection, writing, and submission. **First author**, **corresponding author.**

Paper IV: I was responsible for recruiting and testing healthy individuals at the center in Umeå. I also actively participated in the statistical analysis and writing of the manuscript. **Co-author.**

Preface

I started as an MSc in Sociology, with a side interest in public health and a wish to continue my academic career by doing a Ph.D. However, there were no suitable Ph.D. positions, and I went on to work for a non-governmental organization. Realizing that my interest in public health was increasing, I trained as a physiotherapist instead and moved to get work in a hospital in southern Sweden. As it happened, I got to work with many different people with various diagnoses. However, one of the most giving groups to work with was the individuals with Chronic Obstructive Pulmonary Disease (COPD). As the responsible physiotherapist for the weekly COPD exercise group at the hospital, I went to the Swedish national physiotherapy congress. There, I listened to A/Prof Andre Nyberg talking about how you could modify certain things for people with COPD so that they were able to improve their physical abilities even more. Back at the hospital, I tried out some techniques I had learned at the congress, and they worked! The patients were happy, and I was impressed. About a year following this event, I got a tip from a contact that Andre Nyberg was looking to employ a Ph.D. student for his ongoing project on COPD and exercise. I applied at once. Moreover, I got accepted!

The people with COPD that I have met have been great to work with. They have been curious, talkative, sad, happy, tired, fighters, hopeful, afraid, thankful, angry, active, sedentary, ashamed, and proud. This is a group full of people that want more and that often are not offered what they *should* be offered by the health care system. Whenever resources were scarce at my hospital, the exercise group for people with COPD was the first to be cut. Nevertheless, my patients kept knocking on my door, letting me know that my interventions were wanted and important to them. I always felt like I was making a difference. What more could you wish for in life?

Therefore, to me, this is my starting point for this thesis. This was my opportunity to increase knowledge about how to optimize exercises, how to know and show the need for intervention for the individual and to help this group get the information and help that they so deserve – even when the health care system is strained and is fighting to keep up with the needs of people with COPD. Ideally, our results can make a difference.

Introduction

COPD is one of the leading causes of morbidity and premature death worldwide (1, 2), the cause of suffering for many, and places an economic burden on society (2). It is a systemic disease that affects the whole person, even though dyspnea is the most prominent symptom (3).

According to the Global Initiative for Chronic Obstructive Lung Disease (GOLD), COPD is defined as:

> *"a common, preventable, and treatable disease that is characterized by persistent respiratory symptoms and airflow limitation that is due to airway and/or alveolar abnormalities usually caused by significant exposure to noxious particles or gases and influenced by host factors including abnormal lung development. Significant comorbidities may have an impact on morbidity and mortality."* (2)

Burden of COPD

Prevalence

Data regarding COPD prevalence differ due to varying methods, diagnostic criteria, and analytical approaches. More importantly, however, these studies have only defined COPD by spirometry without taking symptoms into account (2) since this was the ruling definition of the diagnose for a long time. Nowadays, data are emerging where more accurate estimates of disease prevalence are possible. The prevalence of COPD is expected to increase during the coming 40 years due to increasing relevant risk behavior and an aging population. Today we know that COPD is widely under-recognized and under-diagnosed and had a global prevalence of 11.7% in 2010 (4). Further, about 3000 individuals die from COPD in Sweden each year, and the disease prevalence is estimated between 400 000 and 700 000 persons within the country alone (5).

Morbidity

Studies indicate that morbidity due to COPD increases with age and that among those diagnosed, the development of comorbidities may be seen at an earlier age (2). Comorbidities that are related to smoking (e.g., lung cancer), aging, and COPD (e.g., severe dyspnea) may also worsen the

health status of a diagnosed individual significantly, as well as interfere with disease management and increase the risk of hospitalization due to COPD (6).

Mortality

Due to the under-recognition and under-diagnosis of COPD, as well as varying exactness in medical records, the accuracy of mortality data is low (2). Despite this, it is clear that this disease is one of the most important causes of death in most countries (2) as it is the third most common cause globally (7).

Social burden

According to the Global Burden of Disease Study, COPD is an increasing contributor to mortality and disability globally (8). Living with this disease usually means experiencing daily variations in symptoms and a limit in one's ordinary daily activities. This, in turn, can awaken feelings like fear, loneliness, sadness, and anger. Additionally, the experience of an [1]exacerbation can be very scary and lead to even further avoidance of activities – thus leading to a downward spiral health-wise (9, 10).

Diagnostics and disease severity

For anyone that seeks health care, which displays dyspnea, chronic cough or sputum production, and/or a history of exposure to risk factors for COPD, the diagnosis should be considered (2). Spirometry is used to measure the persistent airflow limitation seen in people with COPD and is required to make the diagnosis (11). However, (as indicated above) in addition to spirometry, risk factors and symptoms are essential in diagnosing this disease (2).

When diagnosing COPD and assessing disease severity, one should include an assessment of the individual's symptoms, medical history, and exacerbation history/risk. People with COPD are now classified in a combined assessment into categories A, B, or E, depending on the combination of airflow obstruction severity, assessment of symptoms, and history of exacerbations (2). This is illustrated by the combined assessment tool below (Figure 1).

[1] Exacerbations are acute respiratory events where the symptoms of COPD are increased. These events require specific treatment and preventive actions. © 2022, 2023 Global Initiative for Chronic Obstructive Lung Disease, available from www.goldcopd.org, published in Deer Park, IL, USA.

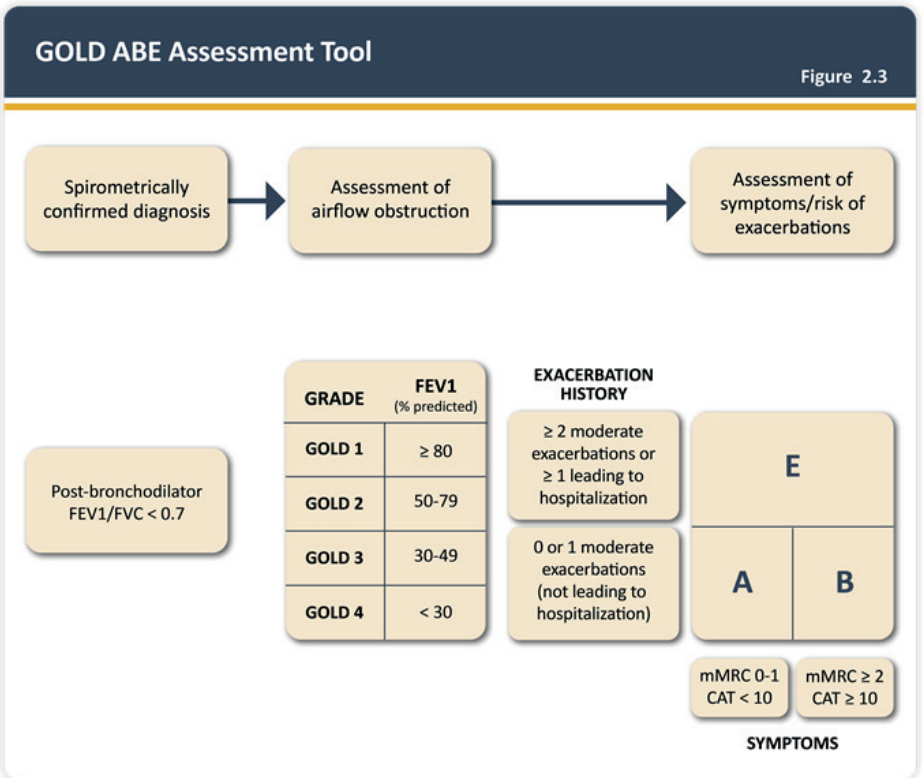

Figure 1. The GOLD combined assessment tool.
Abbreviations: GOLD, The Global initiative for chronic obstructive lung disease; FEV1, forced expiratory volume in the first second; FVC, forced vital capacity; mMRC, modified Medical Research dyspnea Scale; CAT, COPD assessment test. © 2022, 2023 Global Initiative for Chronic Obstructive Lung Disease, available from www.goldcopd.org, published in Deer Park, IL, USA. The traditional assessment of airflow limitation is shown on the left side and is one part of the classification. It is combined with the presence of symptoms and a history of exacerbations. Being categorized into group A means one has a lesser risk of exacerbations and less severe symptoms. In group B, one has a lesser risk of exacerbations and more severe symptoms, while in group E, one has a greater risk of exacerbations, and symptoms can be more or less severe (2).

Symptoms

Dyspnea, of a chronic and progressive kind, is the most prominent symptom of COPD, and about 30% of the COPD population presents with cough with sputum. These symptoms can vary by the day and may precede the development of airflow limitation for several years. However, the decision to seek medical assistance is usually determined by the impact of symptoms the individual experiences regarding their functional status (2).

Besides the symptoms mentioned above, there are several other manifestations as well. Wheezing and chest tightness, fatigue, weight loss, muscle loss, anorexia, depression, and anxiety are other common problems for people with COPD. These symptoms have prognostic value, can be manifestations of comorbidities/other diseases, and/or cause less visible stress on the body (2).

Extrapulmonary manifestations

Although the respiratory system is primarily affected by COPD, it is a complex and heterogeneous disease associated with a range of pulmonary and extrapulmonary manifestations and symptoms, which highly contribute to the daily burden of the disease. An overview of common extrapulmonary manifestations and symptoms is seen in Figure 2. Importantly, extrapulmonary manifestations and symptoms of COPD are highly prevalent, seen independent of the degree of airway obstruction (i.e., GOLD stage), and closely linked to important clinical and prognostic outcomes such as physical inactivity, reduced quality of life, health status, and even prognosis. Of particular interest regarding these extrapulmonary manifestations within the current thesis is skeletal/limb muscle dysfunction, a common secondary consequence seen in approximately a third of all people with COPD (12).

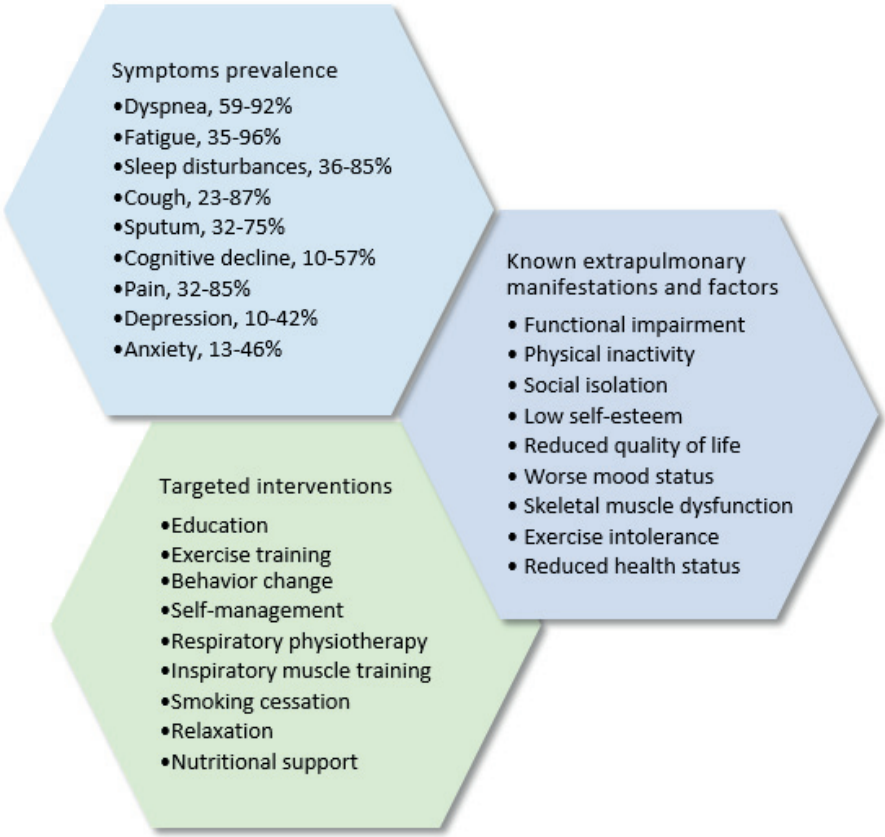

Figure 2. Overview of symptoms prevalence, known extrapulmonary manifestations and factors, and targeted interventions to tackle symptoms burden and consequences within an interdisciplinary pulmonary rehabilitation framework (13).

Skeletal muscle dysfunction

Compared to healthy controls, limb/skeletal muscle dysfunction in people with COPD is evident by intrinsic muscle structural changes that include mitochondrial dysfunction (14), a larger amount of intramuscular fat (15, 16), a shift from muscle fiber type I towards muscle fiber type IIx (17), as well as poor oxidative capacity (18). At the functional level, skeletal muscle dysfunction is, e.g., manifested by reduced skeletal muscle strength (12), as well as reduced skeletal muscle power and endurance (19), where the latter often is reported to a larger extent than the reduction in skeletal muscle strength (20). Skeletal muscle endurance is, e.g., also more closely related to walking and arm function (21). An overview of etiological factors,

morphological and structural abnormalities, and impaired skeletal muscle function is seen in Figure 3.

Reduced muscle strength and mass

Impaired skeletal muscle function is evident by reductions in muscle properties such as muscular strength, endurance, and power, as well as increased fatigability. It is significant to note that this reduction in, e.g., the strength and the endurance capacity of the skeletal muscles, independent of lung function, is intimately linked with important clinical outcomes in people with COPD, such as reduced quality of life (22), exercise intolerance (23-25), greater health care utilization (26) and even increased mortality (27, 28). For example, mid-thigh muscle atrophy has been associated with a 300 % increase in mortality (after adjusting for sex, age, and forced expiratory volume in one second (FEV_1)(27). Moreover, for every 10% increase in the quadriceps strength (kg) to body mass index (BMI, kg/m^2) ratio, research has shown a 9% mortality decrease (15).

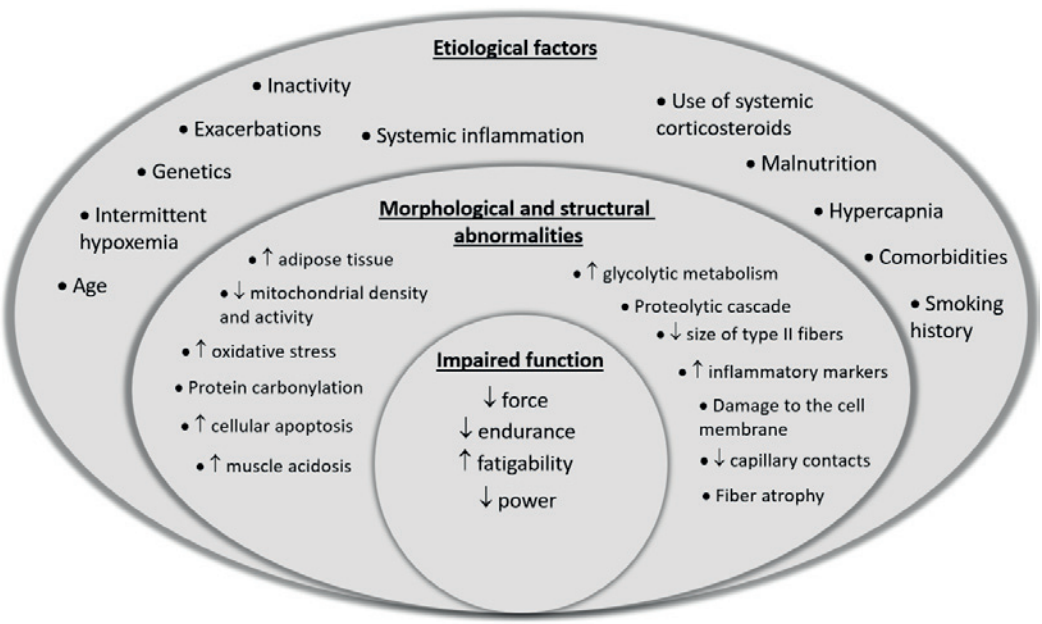

Figure 3. Overview of etiological factors, morphological and structural abnormalities, and impaired skeletal muscle function in chronic obstructive pulmonary disease (29).

Reduced muscle endurance
Skeletal muscle endurance refers to the muscle's ability to sustain or repeat a specific task over time (30). Fatigue, on the other hand, refers to a reversible reduction in force generated by the muscle during a given task (30). It is very common for people with COPD to present with reduced quadriceps endurance (19), often more so than quadriceps weakness (20), and this reduced endurance is highly relevant for daily living tasks (19). When making patient assessments, both endurance and strength should be tested since we cannot predict endurance by knowing muscle strength (25). Additionally, there are different ways to evaluate skeletal muscle endurance, and one should test, e.g., both sustained and repeated contractions (with the help of different techniques) (19). Isometric, isotonic, and isokinetic skeletal muscle endurance measurements have shown a high to very high relative reliability in people with COPD and are, therefore, suitable for use (31, 32).

Reduced muscle power
Muscle power is defined as "The rate of transformation of energy to work or heat" or "the product of force and velocity" (33). This means that muscle **force** is the tension wielded by a given muscle during a muscular contraction against a specific load. **Power** is that same muscle's capacity to wield the same force several times as fast as possible (https://crossdna.com/muscle-power-what-is-it-and-how-to-improve-it/). Muscle power declines as we get older, at an earlier and faster rate than muscle strength and mass (34, 35), it has also been seen as the strongest predictor of functional capacity for people with COPD (36, 37). Furthermore, direct assessment of muscle power using a standardized isotonic protocol has recently shown excellent relative reliability (38).

Measuring skeletal muscle function in COPD

The 2014 American Thoracic Society and European Respiratory Society statement on Limb Muscle Dysfunction in COPD recommends that assessment of isometric skeletal muscle function should be an integrative part of the routine assessment of people with COPD. In addition, measurements of different aspects of skeletal muscle properties (e.g., strength, power, or endurance) during exercise training is recommended as they would provide a mechanism for monitoring progress. Nonetheless, as seen in Figure 4, several factors influence the choice of strategy when measuring and monitoring skeletal muscle function in people with COPD and should be considered when deciding how to assess different muscle properties of skeletal muscle function in COPD.

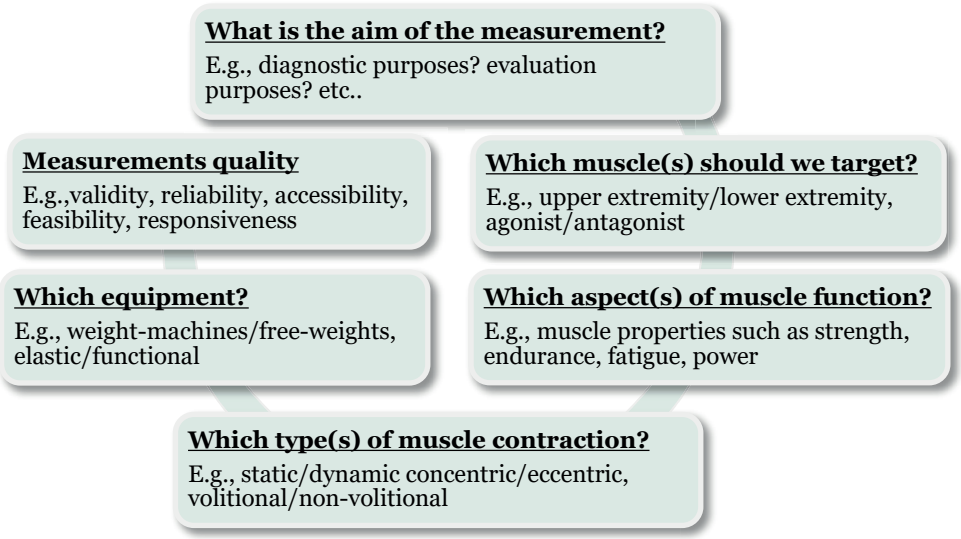

Figure 4. Factors that influence the choice of the measurement technique (29).

Moreover, despite the clinical and prognostic relevance of skeletal muscle function in people with COPD, specific assessments targeting skeletal muscle function are not incorporated in the clinical setting yet, in part because of continued knowledge gaps. The lack of valid and reliable measurement techniques, other than for muscle strength, has for a long time been a critical obstacle. However, as shown above, recent work by our research collaboration(s), and by others has led to the development of valid and reliable techniques for other skeletal muscle properties (than muscle strength). For example, Frykholm et al. have shown that skeletal muscle endurance could be reliably measured using isokinetic, isometric, and isotonic techniques and that skeletal muscle endurance, in particular isotonic measurements of endurance, was the strongest predictor of daily life physical activity when compared to muscle strength and power. About the latter, Gephine et al. also demonstrated the importance of measuring skeletal muscle power being both highly reliable and the strongest predictor of functional performance in COPD.

Taken together, recent findings not only support the measurement of skeletal muscle function in COPD but also emphasize that different muscle properties should be measured depending on the aim of the measurement. Thus, emphasizing the importance of measuring not only the strength capacity of the muscle but also other muscle properties such as skeletal muscle power and endurance.

Still, remaining obstacles exist before assessments of skeletal muscle function can be implemented within the clinical context, two of which are the lack of reference values and valid reference equations. For example, the available equations to predict reference values of skeletal muscle strength (39, 40) have a low predictive ability and have not been embraced by the pulmonary community. A substantial problem is that their construct validity has not been documented in the COPD group. Besides that, other than for isometric (static) muscle strength (41), there are no reference values or reference equations available regarding dynamic muscle strength or either static or dynamic skeletal muscle endurance or power. Thus, this suggests that reference values for muscle testing in COPD are highly needed to improve the care available to this group of patients (29, 38).

Evidence-based treatment

As previously stated, the management of COPD ought to be based on symptom assessment and the estimation of future risk of exacerbations. Management of COPD ultimately tries to reduce symptoms and risk factors, and it includes both pharmacologic and non-pharmacologic treatments (42). An overview of the spectrum of support needed for people with COPD is shown in Figure 5, emphasizing the complexity of the disease and the need for comprehensive support and management.

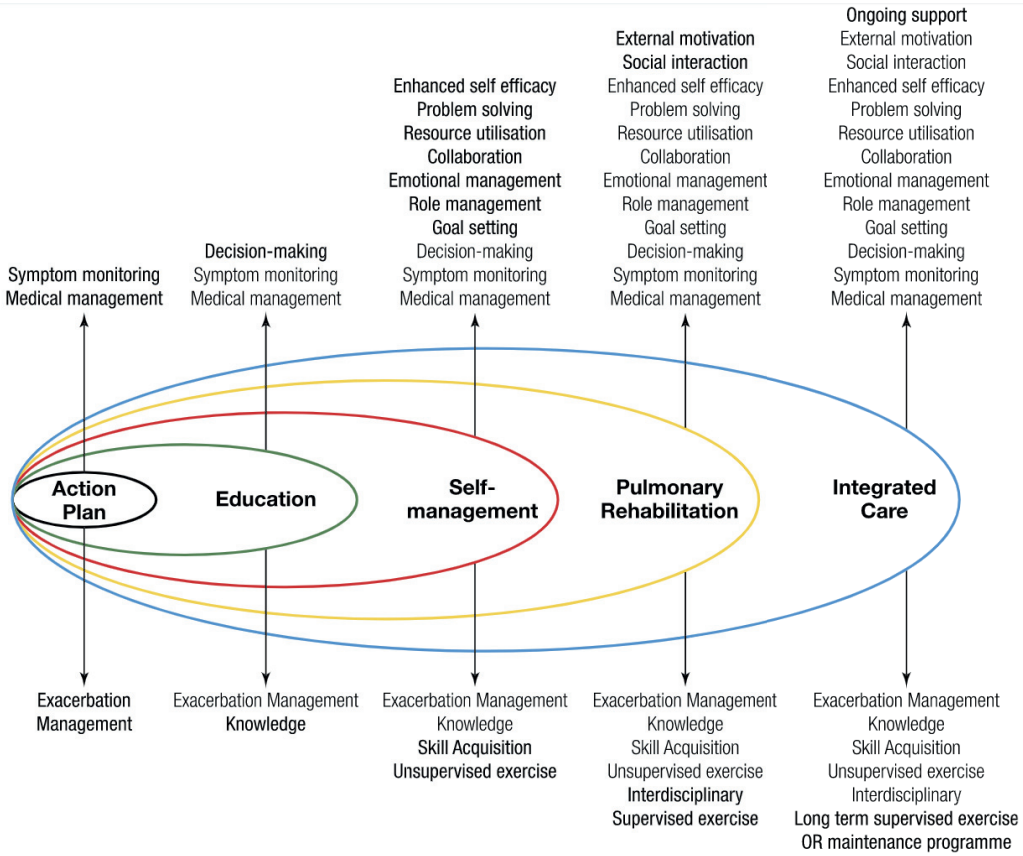

Figure 5. "A spectrum of support for chronic obstructive pulmonary disease (COPD)". Reprinted with permission from Reference 44. (44)

Smoking cessation and vaccination

A common risk factor that should be addressed is smoking. Smoking cessation should be encouraged and supported by all health care professionals (HCPs) involved since quitting smoking can reduce the airflow decline to a rate comparable with never-smokers (45, 46). This includes full suitable programs, nicotine substitutes, and accompanying counseling (47). The risk of attaining seasonal influenza and pneumococcal infections is essential to reduce by, for example, vaccination (48, 49) and, of course, avoidance of interaction with infected persons. This, in turn, can reduce the risk of getting seriously ill, premature death, and exacerbations by up to 40% (50).

Pharmacological treatment

Pharmacotherapy is integral to the COPD management strategy since it can prevent and control symptoms, lessen exacerbations and help increase exercise tolerance (43). By taking their medications, a person with COPD can, for example, exercise their body to a greater extent than without it – thereby having a better chance at increasing their overall health status and improving the prognosis in the long run (43). There are several commonly used medications, for example, bronchodilators (to reduce dyspnea and hyperinflation and increase exercise capacity) and anti-inflammatory substances (to reduce the risk for exacerbations) (2).

Non-pharmacological treatment

During exercise in people with COPD, where proper ventilation, such as lung emptying or adequate oxygenation, is hard to reach, oxygen supplementation, noninvasive ventilation, or breathing strategies are used (43). Also, walking aids are useful for assisting with movement, feeling safe during ambulation (both for steadiness and resting), and helpful when carrying an oxygen cylinder, for example (43).

Pulmonary rehabilitation

Pulmonary rehabilitation is commonly used for non-pharmacological treatments that focus on the active participation of the person with COPD. Pulmonary rehabilitation is defined as:

> *"a comprehensive intervention based on a thorough patient assessment followed by patient-tailored therapies that include, but are not limited to, exercise training, education, and behavior change, designed to improve the physical and psychological condition of people with chronic respiratory disease and to promote the long-term adherence to health-enhancing behaviors." (43)*

It is, since many years, an essential component in providing high-standard care for people with COPD, and there is strong evidence that pulmonary rehabilitation significantly improves quality of life, symptoms, and exercise capacity and reduces the need for hospitalizations (13). Developments on how to best optimize the delivery and outcomes of pulmonary rehabilitation are ongoing, and during the last few years, new insights have been seen. This includes evaluations of behavior change approaches and physical activity promotion evaluations, recognition of important attributes like comorbidities and frailty for pulmonary rehabilitation content, delivery, and outcomes, etc. (13). It is, however,

important for these new insights to be used in clinical settings if pulmonary rehabilitation is to reach its potential (13).

Education, self-management, and behavior change

Education is part of pulmonary rehabilitation and refers to the facilitation of learning and gaining knowledge and skills (51, 52). Education aims to enhance the psychological and physical status of people with COPD and other chronic lung diseases. It also aims to enhance long-term adherence to health-improving behavior (43).

Pulmonary rehabilitation has gradually adopted an approach that means to enable adaptive behavior change through self-management (53, 54). This approach sees people with COPD as experts in their own lives while adding medical expertise from HCPs. Through this personalized approach, the goal is to motivate, engage, and support people with COPD to achieve goals and address behavioral risks – as well as monitor and manage their disease (13, 55). Some of the points of self-management include being able to recognize and properly respond to an exacerbation, acquiring strategies for managing breathlessness and coughing, etc. (54). Importantly, for this thesis, self-management interventions within PR are meant to empower people with COPD by, e.g., motivate, engage and support these individuals (13).

As the population is aging and chronic lung diseases increase in prevalence, we require new ways to educate, support, and manage symptoms for the sake of people with COPD (13). Digital health information has been increasingly used for this purpose, to (among other things) facilitate exercise at home, self-monitoring (e.g., with step counters), self-treatment (e.g., self-management web portals), and to detect exacerbations early (e.g., via disease education) (56-60). However, the digital resources available for people with COPD are diverse in terms of content and quality (61) – which logically means that the research needs to make sure these resources are reliable, valuable, engaging, and safe for people with COPD to use.

Focusing on behavior changes is especially appropriate after hospitalizations and other meaningful events, partly because these events can bring about an awareness of one's need for change (62, 63). To make a real change, however, time and bite-sized goals are needed, which means that more long-term programs are more suitable (64). Importantly, this kind of intervention also includes the values, attitudes, and experiences of people with COPD (62), and according to earlier research changing one's

behavior usually takes over two months and is fairly complex (57, 65) and is an important part of managing one's COPD. This can be demanding on persons with COPD as they are handling intricate everyday routines and tasks on their own. This is where self-management interventions can be an effective help in building and executing long-lasting behavior change practices (66).

Within pulmonary rehabilitation, the social cognitive theory and the theory of planned behavior (66) are the most commonly applied theories regarding behavior change in chronic lung disease. Key points in these theories are, in short, related to the individual's resources to execute the change and the rewards of the outcome of the change, as well as the individual's perception of the change, social norms regarding the change, and the amount of control that the person has (66). These theories are thought to explain how to attain behavior change in people with, e.g., COPD. However, they are not representing the inner workings of every individual diagnosed with this disease.

Exercise training

Considered a keystone of pulmonary rehabilitation, individually adjusted exercise training is one of the essential components of the management of COPD (43). Of importance, the general principles of exercise training in people with COPD are no different from those for healthy individuals or even athletes (67). For exercise training to be effective general exercise principles such as specificity, progressive overload, and variation should be followed. For example, the total training load must reflect the individual's specific requirements, and it must exceed loads encountered during daily life to improve aerobic capacity and muscle function. Independent of the modality used, exercise loads must progress as improvement occurs (43).

Even though various modes of exercise can be used (and are required) depending on the goal of treatment, endurance and resistance training are critical components of exercise training in people with COPD (43).

Endurance training

Mostly walking or cycling is used as endurance training in pulmonary rehabilitation (43, 68, 69). Walking is also a functional exercise and, of course, the number one choice if the treatment aims for walking endurance (43). People with COPD are recommended to adhere to the American College of Sport Medicine recommendations regarding continuous endurance exercise (67). However, reaching the

recommendation of higher intensity continuous training can prove challenging for someone suffering from COPD. Using interval training may be a way to reach these intensities and durations (69). According to earlier research, interval and continuous endurance training seem to be interchangeable in effect (43, 70).

Resistance training

Resistance training has shown the same positive effects as endurance training (71) and is considered an efficient and practical intervention in people with COPD (72, 73). Following the principle of specificity, resistance training executed according to current treatment guidelines (i.e., 8-12 repetitions on a load corresponding to 60-70% of the one-repetition maximum) is especially effective when the aim is to enhance muscular mass and strength (72, 74-77). However, if the goal is to improve the endurance capacity of the muscle, using a higher number of repetitions and a lower load (i.e., >15-20 repetitions on a load corresponding to 45-55% of the one-repetition maximum) is recommended and have shown to improve not only the endurance capacity of the muscles but also functional capacity such as walking distance on the 6-minute walk test (6MWD) (78, 79). As for general resistance training recommendations, resistance training should, independent of the goal being to increase the strength/mass or the endurance capacity of the muscle, preferably include lower- as well as upper-extremity exercises. As a minimum, exercises targeting the quadriceps (e.g., knee extension or leg press) should always be incorporated (80). Although resistance training designed to increase muscle strength/mass has a narrow effect on other results, such as the functional capacity of the lower extremity, dyspnea, and quality of life (72, 73, 81), it also produces less dyspnea during exercising and thus provides an opportunity for those plagued by breathlessness (82).

Oxygen supplementation

Oxygen is one of the most important components within hospitals when treating hypoxemia in persons with COPD with acute respiratory failure (83). Long-term supplementation can increase survival for individuals with severe resting hypoxemia but those with mild to moderate symptoms (84). There is no unison evidence that oxygen supplementation improves the effect of exercise interventions either (85).

Surgical treatment

In some individuals with severe COPD, emphysema, and hyperinflation, there can be surgical options to lessen symptoms (86) – such as lung volume reduction surgery. The purpose of the operation is to restore the

lung to a more functional shape and a smaller volume to improve long-term functioning (86). However, the procedure also comes with great risk (86).

Knowledge dispersion

As highlighted above, optimal testing and exercise methods are highly important to optimize COPD management. Even so, there are more hurdles to jump to reach optimization, and one of them is to reach the clinical setting**.**

For example, despite the overwhelming evidence in support of pulmonary rehabilitation including exercise training for people with COPD, only a limited proportion of people with COPD get access to such services (87, 88). For example, in Swedish primary care, there is a large gap between COPD treatment guidelines and the health care provided, despite the high availability of health care professionals for rehabilitation (89). Lack of education, knowledge about treatment guidelines, and limited access has been found to be barriers among health care professionals (89-91). Among people with COPD, lack of knowledge and insight into their diagnosis, travel issues, and changing health limited their participation in pulmonary rehabilitation (92-94). Thus, this calls for alternative strategies.

eHealth

Mobile applications (apps) and web-based platforms are two of the so-called electronic health (eHealth) tools that, over the last decade(s), have been put forward as promising alternative ways of mediating knowledge and support regarding self-management strategies to people with COPD. These eHealth tools are becoming more and more frequent in use, e.g., for intervention, disease education, and monitoring health status, as the tools have revealed themselves as feasible and effective within the COPD population (95-103). Further, eHealth tools are believed to be a keystone in relaying health-related information (97, 98, 102, 103).

There are eHealth tools that require internet access and those that do not. Among the former, various communication and information technologies are adopted to bridge long distances and the like, to improve access to various services provided by health care. The intention, ultimately, is to improve the health of care recipients (104). During the COVID-19 pandemic, the need for health care distance solutions has been even

greater within pulmonary rehabilitation. According to recent research (13), people with COPD have been generally positive towards using internet-based programs, but still, there's been a low level of enthusiasm to participate in these programs – and data on that topic are likely under-reported.

However, there is also a selection bias, where there usually is a very specific group that can and will engage in these internet-based pulmonary rehabilitation programs (13), which indicates that more research on a wider patient group base is needed. Additionally, while more and more trial data back the effectiveness of internet-based pulmonary rehabilitation programs, indicating them to be a budding useful alternative to conventional programs, a lacking homogeneity in studies warrants more research (13). Earlier research has also looked into important things to consider during eHealth tool designing (105-107), however, less is known about user behavior over time. Especially, factors associated with the use of eHealth tools over time are not studied enough.

The COPD Web

The COPD Web is an interactive webpage developed by colleagues at Umeå University, in co-creation with people with COPD, their relatives, as well as health care professionals working with people with COPD (99, 108). It was developed to help to overcome the insecurity and knowledge gap for both health care professionals and people with COPD (89). A website map of the content of the COPD Web from the perspective of people with COPD is seen in Figure 6.

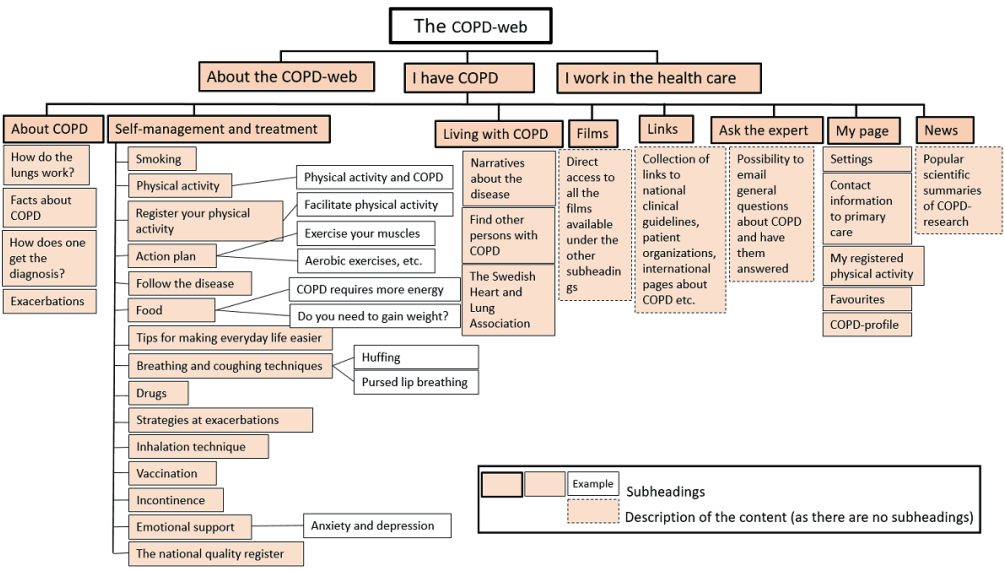

Figure 6. A website map of the COPD Web showing the section 'I have COPD'. COPD: chronic obstructive pulmonary disease (100)

As seen in Figure 6, the COPD Web has several sections; "I work in health care", "I have COPD", "I am related", and "Home health care/education". Within the studies/articles in this dissertation the focus has been on the two former sections (aimed at HCPs working with COPD [**Paper II**] and at people with COPD [**Paper I and Paper III**]).

The web page is based on the recommended non-pharmacological health promotion interventions regarding COPD management in Sweden (109) and the content includes informational texts, explanatory pictures, and videos, as well as some interactive components. The COPD Web aims to mediate knowledge/information, techniques/strategies, and support for COPD management. The user creates a login and gets a "personalized front page" where they can put content that is especially important/relevant for them. For people with COPD, there is an interactive function of filling in their physical activity level, setting goals, as well as getting automated feedback. All content is possible to print, enlarge, and tag for future revisiting in line with what was particularly emphasized in the co-creation process (99).

Outside the scope of this thesis, the COPD Web has been found to be feasible and can increase COPD-specific knowledge of HCPs in long-term care, leading to an increased focus on COPD-related issues (110). Among

people with COPD, the use of the COPD Web has been shown to be an effective shorter-term (3-month) strategy to increase self-reported physical activity, and conceptual knowledge and to alter disease management strategies (111). However, as the general use of the COPD Web among people with COPD varied profoundly, and the vast majority mainly used the platform during the initial month, less is known about user behavior over time. Specifically, knowledge of factors associated with using eHealth tools, such as the COPD Web over time, is sparse.

Lastly, since the content of the COPD Web is built on national and international treatment guidelines (109), the COPD Web also includes information on both training and testing methods. Thus, the COPD Web could support facilitating and promoting access to, e.g., reference values, and predictive equations that are developed as part of my thesis work (**Paper IV**), but also for identifying the best training strategies for enhancing skeletal muscle function. However, at first, the usability, user-friendliness, and potential benefit of eHealth tools need to be determined.

Theoretical framework

For my research studies, the aspiration was to explore and learn more than one "way" to do research. Since then, the dissertation has evolved following the four studies within the dissertation. The theoretical framework has, in much the same way as the dissertation itself, developed throughout and has not been meant to shape the studies or published articles. Rather the theoretical framework can be seen in retrospect as it is closely related to the research questions and the following methodological choices. Based on the objectives of my studies, I used both quantitative and qualitative research methods. Between the quantitative and qualitative flanks, there is a continuum of different epistemological and ontological positionings (Figure 7), which guides the methodologic choices. Simply put, ontology is how we see the world, epistemology is how we perceive that knowledge emerges, and methodology is how we intend to reach that knowledge (112, 113).

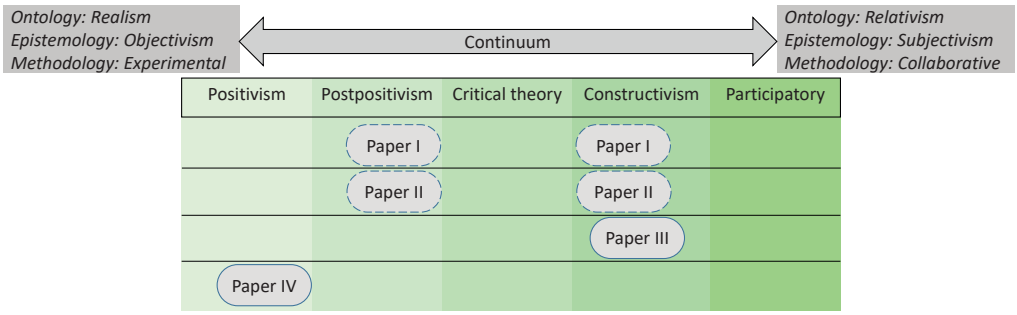

Figure 7. Simplified map of the continuum of research paradigms and an attempt at placing my work within it.

Ontological, epistemological, and methodological assumptions

As stated above, the research questions of the various studies within the dissertation have shaped the paradigms used in my work. The dissertation is, in part, displaying more realism and objectivism, and in part, more relativism and constructivism. This is related to utilizing both quantitative and qualitative research methods during the varying parts of the thesis. For example, **Papers I**, **II**, and **III** show a more constructivist ambition, with a relativist view. **Paper IV**, instead, has a close connection to realism and objectivism.

Physiotherapy theory

Within physiotherapy, there are quite a few theoretical frameworks available, and as professionals, we adhere to those that best serve our task at hand (114). A common denominator between these theories is that physical movement is regarded as both a means and a goal (114). Emerging in my work is the all-embracing physiotherapeutic theory, "the movement hierarchy" (rörelsehierarkin) (114). It covers three levels of movement; conditions for movement, movement ability, and movement behavior. These levels include aspects from the purely physical to the more psychological and environmental (114). Again, as an example, **Papers I**, **II**, and **III** include the preconceptions that movement depends on and interacts with the physiological, psychological, social, and otherwise contextual factors that the individual exists in/with. **Paper IV** works within the assumption that an alteration of the individual's type of movement, as well as the dosage of that movement, can effect the movement, or function, of daily life (114).

Rationale

Despite overwhelming evidence in support of pulmonary rehabilitation for COPD management, only a limited proportion of people with COPD get access to those services. In Swedish primary care, there is a significant gap between COPD treatment guidelines and the provided health care, despite a good amount of health professionals for rehabilitation. Among health care professionals there is a lack of education, knowledge about treatment guidelines, and limited access, and among people with COPD, there is a lack of knowledge and insight, mobility issues, and fluctuating health that limits their participation in pulmonary rehabilitation. This calls for alternative strategies.

The COPD Web is an interactive web page developed in co-creation with people with COPD, their relatives, and health care professionals working with people with COPD. The aim was to bridge the insecurity and knowledge gap for both health care professionals and people with COPD. As the content of the COPD Web includes (but is not limited to) both training and testing methods, this tool could be one way to promote and facilitate access to reference values and predictive equations that are developed and explored in this research project (see below). However, at first, the usability, user-friendliness, and potential benefit of the tool need to be determined (aims of **Papers I-III**).

Lastly, despite the clinical and prognostic relevance of skeletal muscle function in people with COPD, specific assessments targeting different skeletal muscle properties are not incorporated in the clinical setting yet, partly because of continued knowledge gaps. For instance, the available reference equations to predict normative values of skeletal muscle strength have a low predictive ability and have not been embraced by the pulmonary community. A substantial problem is that their construct validity has not been documented in the COPD group. Besides that, other than for isometric (static) muscle strength, there are no reference values available regarding dynamic muscle strength or regarding either static or dynamic limb muscle endurance, or muscle power. Thus, this suggests that reference values for muscle testing in COPD are highly needed before the assessment of skeletal muscle function could become a reality in the clinical setting (aim of Paper IV)

The overall aims of the doctoral thesis

The overall aim of this thesis is to explore the conditions for, and perspectives on, evidence-based care and eHealth in COPD management. This aim is twofold. The first is to explore the experiences, interactions, and context of the management of COPD in primary care from the perspective of people with COPD and HCPs. The second is to develop reference values and equations for thigh muscle function.

- To explore and describe the experiences of people with COPD regarding using an eHealth tool over time and factors that might affect usage (**Paper I**)

- To explore the experiences of using an eHealth tool among HCPs that worked with people with COPD in daily clinical practice (**Paper II**)

- To identify enablers and barriers for the use of web-based support with the COPD Web in order to change behavior (**Paper III**)

- To 1) develop reference equations to obtain predicted values for quadriceps strength, endurance, and power in healthy individuals, 2) test the reference equations in people with COPD to establish the prevalence rate of reduced muscle strength, endurance, and power in this population, and 3) explore the construct validity of the proposed equations by documenting and evaluating the relationships between quadriceps properties and functional capacity in people with COPD (**Paper IV**)

Materials and Methods

This doctoral thesis contains three papers (**Papers I**, **II**, and **III**) based on individual interviews analyzed with qualitative research methods and one paper (**Paper IV**) based on international multicenter data collection analyzed with quantitative research methods. The papers have been written in collaboration with national, international, and interprofessional co-authors from Sweden, Canada, and Belgium.

Table 1. Overview of the included Papers in this thesis.

	Paper I	Paper II	Paper III	Paper IV
Study design	Qualitative content analysis (interview study)	Qualitative content analysis (interview study)	Constructivist Grounded Theory (interview study)	Multiple and separate linear regression analyses, and Pearson's correlations
Part of main project	Controlled pragmatic pilot trial	Controlled pragmatic pilot trial	Pragmatic RCT	International multicenter cross-sectional study
Research collaborations	Umeå University, Högskolan Dalarna; Karolinska Institutet	Umeå University, Högskolan Dalarna	Umeå University	Umeå, Sweden; Quebec City and Toronto, Canada; Diepenbeek, Belgium

RCT = Randomized Controlled Trial.

Study designs

Qualitative content analysis studies; an overview (Papers I and II)

The overall trial design for this study was a parallel-group (1:1 allocation) controlled pragmatic pilot trial with pre-and post-assessments, and parallel process evaluation. It included six publicly funded primary health care units (two situated in the north, and four in the south, of Sweden) that were invited to participate as study sites (115). As part of the study, semi-structured individual interviews with 1) people with COPD that had access to the COPD Web during the controlled pragmatic pilot trial (**Paper I**) and 2) HCPs working with people with COPD in the health care

setting (**Paper II**) were performed. The HCPs themselves also had access to the COPD Web as a work tool during the trial mentioned above.

Study design
A qualitative interview study with an inductive approach according to Graneheim and Lundman (116) was used for both **Paper I** and **Paper II**, to explore meaning in already existing data as it also offers the possibility to utilize quantifiable information within (which we eventually used in **Paper I**) (117). Interviews were conducted at 3 and 12 months as 3 and 12 months are commonly used when investigating intervention-based effects in people with COPD (96, 97). Other study procedures are described in more detail separately for **Paper I** and **Paper II** below.

Participants
People with COPD: All persons with a diagnosis of COPD (ICD-10:J44:9) who visited one of the included primary care units due to their COPD during a 4-month period were eligible for inclusion in the study if they 1) could read and understand Swedish or 2) could be assisted in their use of the COPD-web by a person who reads and understand Swedish. Recruitment of potentially eligible individuals was performed by HCPs at the primary care units, respectively (**Paper I**).

Health care professionals (HCP): One or two HCPs at each primary care unit were identified and included in the study. Eligible for inclusion were HCPs who meet people with COPD in clinical practice (**Paper II**)

Further description of the trial is done separately for **Paper I** and **Paper II** below.

Qualitative content analysis study; People with COPD (Paper I)

Sampling
The main (process evaluation) study included 83 people with COPD; out of these 43 were randomized to the intervention group and had access to the eHealth tool, the COPD Web. Of those randomized to the intervention group, a minimum of 3 persons with COPD at each of the 5 units were contacted and asked to participate in the individual interviews.

Purposeful sampling was utilized to ensure there was at least one woman/man with COPD at each primary health care unit. To be included in this trial, participants had to be able to read and understand Swedish or be assisted by someone with this capacity when using the eHealth tool.

To further ensure the privacy of the persons with COPD, all names were changed to pseudonyms at the start of the analysis, so that only the interviewers and analyst knew their real names.

Participants and setting
Sixteen persons with COPD (12 women, 4 men), ages 48-86, accepted to take part in an individual face-to-face interview 3 months after the intervention started. Of these interviews, 15 were conducted at the participants' homes and 1 at a university (the worksite of the interviewer), according to the wishes of the participating individuals.

For the second follow-up interview, 12 months after the intervention started, 7 (5 women, 2 men) of the previous 16 accepted a second individual interview. This time the interviews were conducted over the telephone. Reasons for declining an interview at 12 months included not having used the COPD Web at all between the first and second follow-up.

During the interviews only the researcher and the person with COPD were present and audio recordings were made using a Dictaphone. Interviewers could choose to take short field notes for the interviews, which one of them did and one of them did not. Field notes were then used as a means of recollection during analysis.

Data generation
One-on-one interview sessions between investigator and participant either in person or via telephone, followed by transcription and subsequent coding as well as categorizing. Information such as age, sex, civil status, occupation, physical activity, smoking habits, and educational level was obtained through a standardized questionnaire while information on lung function was obtained from medical records (115).

Experiences related to the usage of the COPD Web over time were gathered through individual semi-structured qualitative interviews. An interview guide consisting of 5 main areas was used as a framework for the interviews. Main areas of the interview guide: 1) user habits, 2) user experience, 3) accompanying parts (that is, introduction, pedometer, and electronic newsletter), 4) potential effects, and 5) future use.

Questions were posed in an order that followed the storyline of the participant, regarding all main areas, during the interviews. At the 3-month follow-up, the interviews lasted between 7-40 minutes (median 25 minutes), and at 12 months between 4-14 minutes (median 8 minutes). Some interviews were very short due to the interviewee not having used the eHealth tool enough to form an opinion that they were able to

articulate. The follow-up interviews were, in addition to this, shorter due to the interviewees already having a good idea of what the interview looked like.

To further understand the result from the interviews, we also gathered quantitative information on how they, e.g., perceived that their disease affected their daily lives, if they experience shortness of breath, and their capability to find, understand and use information and services to make informed health-related decisions. The following instruments were used: the COPD Assessment Test (118), the modified Medical Research Council Scale (119), and the Communicative and Critical Health Literacy (CCHL) Scale questionnaire (120). Also, the use of the COPD Web by the individuals participating was measured automatically from the website and that data included the 1) number of visits (logins), 2) pages used, and 3) time spent on the website (115).

Regarding the interviews, no immediate callbacks were made to the persons with COPD (for example, for potential amendments or additional questions). Topics raised during the interviews, considered interesting or unexpected, were discussed and used to guide follow-up questions during the following interviews. An experienced third-party transcriber transcribed the interview audio recordings verbatim, the transcripts were then verified by the authors by comparing them with the audio records (121). Transcripts were not returned to participants for comment or correction, and persons with COPD were not engaged to provide feedback on the findings. This exploratory qualitative study was presented in line with the Consolidated Criteria for Reporting Qualitative Research (COREQ) guidelines (122).

Qualitative content analysis study; Health care personnel (Paper II)

Study design

Primary care was targeted since this is where most people with COPD in Sweden are treated (91, 123). The HCPs were instructed to introduce the COPD Web to all people with COPD that they met during those three months, using a pre-specified routine (Box 1). HCPs were invited to participate using convenience sampling.

Box 1. Modified introduction of the COPD Web to persons with COPD by the HCPs (115).

► Registration and creation of an account for the person with COPD to use the COPD Web

► Introducing the website structure, the content in the main menus, and the functions of the website, for example, how to enlarge or reduce the text, listen to the text, or bookmark information of particular interest

► Introducing the "physical activity and exercise training" section to the person with COPD. The HCP will discuss the importance of physical activity/exercise training, point out the films with muscle strengthening exercises, and the page for registering physical activity (steps) with automated feedback

► Introduction of two to four additional topics on the website of particular interest for the specific individual in question

► Topics of specific interest for the person with COPD will be noted on a leaflet with information about the COPD Web. The individual will receive the flyer and a card with the COPD Web's URL address, user name, and password.

Besides the pre-specified routine and in line with the pragmatic approach of the study, the HCPs were free to use, or not use, the COPD Web as they deemed suitable or appropriate. No extra resources were provided to the primary care units as HCPs used the COPD Web as a part of their regular work practice (115). To ensure the HCPs' privacy, all names were changed to pseudonyms at the start of the analysis, so that only the interviewers and analyzing author knew their real names.

Sampling

The senior manager at each primary care unit helped identify health care professionals eligible for participation in the study. Potentially eligible HCPs at the included centers were contacted via telephone or email regarding participation in the study. HCPs, regardless of their profession (e.g., nurses, physicians, physiotherapists, occupational therapists, or dietitians) should 1) meet people with COPD in their daily clinical practice and 2) be willing to use an eHealth tool, the COPD Web, as part of their clinical praxis for a minimum of three months.

Participants

Overall, 10 HCPs (four women, six men), including five nurses, two physiotherapists, one dietician, one occupational therapist, and one

physician, with a mean age of 50 ± 11 years and 25 ± 11 years of work experience, participated in the interviews. Five of them also accepted interviews at 12 months. Reasons for declining an interview at twelve months included not using the eHealth tool (n=4) and being retired (n=1).

Data generation

At the first follow-up occasion, semi-structured individual interviews (except one made in pairs) with open-ended questions were conducted at the participants' workplaces. For the second follow-up at 12 months after getting access to the COPD Web, the interview was conducted via telephone instead. During all interviews (except for the one made in a pair) only the HCP and the interviewer were present and audio recordings were made using a Dictaphone. No immediate callbacks on the interviews were conducted (i.e., for potential amendments or additional questions). Still, exciting, or unexpected topics raised during the interviews were discussed and used to guide follow-up questions during the following interviews. The three-month interviews ranged between 12 and 67 minutes (mean of 39 minutes), while the twelve-month interviews ranged between 10 and 29 minutes (mean of 19 minutes). The interviews were guided by an interview guide including questions about their experiences of using the eHealth tool, its applicability and usefulness, the knowledge support and added value, as well as what they thought was missing when using the eHealth tool when working with people with COPD in primary care. For example, the first question was: "Tell me about if/how you have used the COPD Web (during this time)?" The HCPs were encouraged to speak freely in responding to the questions, and the interviews proceeded as conversations. Transcripts were not returned to HCPs for comment or correction, and they were not engaged to provide feedback on the findings. The study was presented in line with the COREQ guidelines (122).

Constructivist grounded theory study (Paper III)

Study design and setting
This study was part of a pragmatic randomized control trial (RCT). It included process evaluation and in-depth interviews performed with people with COPD between the 3- and 12-month follow-ups after first getting access to the COPD Web (124). The RCT was registered at ClinicalTrials.gov identifier: NCT03746873, and eligible to participate were individuals with a COPD diagnosis treated in primary health care.

The methodology used within **Paper III** was Constructivist Grounded Theory (CGT), following Charmaz's (125) writing and description of the researcher's part in the research process. For example, this means adhering to the assumption that previous knowledge and experience with the researchers will influence choices when investigating, interviewing, analyzing, and presenting research (125). Purposive sampling included people with COPD from the RCT intervention group who accepted being contacted regarding an in-depth interview.

A practical approach was originally chosen regarding interviews. We preferred face-to-face interviews when the person with COPD lived near enough to reach in a day by bus or train and telephone interviews when they lived further away. However, by the fourth interview, COVID-19 restrictions were launched, and all following interviews were thereafter conducted via telephone. Therefore, the two first interviews were conducted in person in a place of the participants choosing (both times in their own homes), and the rest of the interviews were conducted via telephone. All of the interviews were recorded using a Dictaphone.

Participants
To reach our objective and enhance transferability (126), the selection of participants was based on five factors. We wanted the participants to have used the eHealth tool in various amounts, to have had various developments in their step counting, to live in different places in Sweden, to have started the project in different seasons of the year, and we wanted to talk to women and men. In short, we wanted to hear from people with perhaps a bit different experiences or contexts, who still had used the tool and reported the data we asked for. Data we asked for was: how many times the person with COPD had reported visiting the COPD Web after receiving a prompt (SMS and e-mail) (low [0-25% of the times after receiving a prompt]/medium [>25 to 50%] /high [>50%]), increase/no change/decrease in step count, geographical location (urban/rural,

north/middle/south), start date, and sex. Later on, theoretical sampling was used to confirm or disconfirm our findings [26]. For the theoretical sampling, persons with COPD were chosen according to whether they seemed to have information regarding the specified questions.

The purposive sampling led to 13 persons with COPD (7 women, 6 men) between the ages of 49 to 84, living in eight municipalities in Middle and Northern Sweden. Among these individuals, at the RCT's 3-month follow-up, six had increased their objective physical activity level by a minimum of 600 steps/day, three had an unchanged physical activity level (± <600 steps/day), and the remaining four had decreased their physical activity level by ≥600 steps/day. The theoretical sampling included three persons with COPD (two women), ages 69-75, living in three different Middle and Northern Sweden municipalities.

Data generation

The participating persons with COPD were contacted via telephone after their 3-month follow-up to reaffirm their interview stance. All except one still accepted the interview. The reason for declining participation was not declared. The persons with COPD chose the preferred time, date, and location for the interview. They were asked to set aside one hour for the interview to minimize the risk of anyone feeling rushed. People with COPD were recruited through primary health care units in different county councils in Sweden and advertisements in local and national newspapers.

Data was collected through individual semi-structured qualitative interviews, and an interview guide was used as the framework for the interviews. Questions or the interview guide were not provided beforehand to the ones participating. The interview guide consisted of the following main areas: action/agency, seeking of information, expectations, health, lifestyle change processes, and technique/IT (see Appendix 1). Interview questions were asked in an order that suited the conversation best. Still, all main areas were touched upon during the interviews. The duration of the interviews from the first sampling lasted from 41 – 103 minutes, while the interviews from the second sampling lasted between 27 – 76 minutes. The length of the interviews depended on how much the person had to say about the subjects in question. All interviewed persons were assigned a pseudonym used for protecting their identity.

All interviews started with a brief introduction of the interviewer's background and the intention of the interview. To create an open, safe,

and welcoming climate, the participants were encouraged to feel free to ask questions, omit answers, halt the interview or ask for clarifications whenever (and without being questioned) throughout the conversation. All authors are certified physiotherapists, wherein two authors have previous experience and knowledge regarding the GT method.

In most interviews, only the interviewer and the person with COPD were present, while some had their spouse in the vicinity during the interview (or part of the interview). Audio recordings and shorter field notes were utilized. Two immediate callbacks were made on the interviews (to clarify previously given information and ask a few additional questions). One person called the researcher back with further details soon after the interview. All persons participating gave their verbal consent to being contacted again if need be. After each interview, the interviewer read and listened through the material and wrote down any additional field notes. The interviewees were not engaged in providing any feedback on the findings. Topics of interest raised during interviews resulted in added or modified questions for the upcoming interviews. The study was presented in line with the COREQ guidelines (122).

When analyzing and presenting our results, the Fogg Behavior Model (FBM) was used to illustrate how motivational levels, ability levels, and functional triggers interact within our findings. The FBM was used to interpret our findings further since our data seemed to exhibit the same crucial behavior change factors as the FBM mentions. The FBM is not flawless but offers assistance in clarifying the interconnections of our findings. To briefly explain the FBM, there are three factors that need to exist simultaneously for a target behavior to happen: sufficient motivation, sufficient ability, and an effective trigger.

Cross-sectional multicenter study (Paper IV)

Study design and setting
This cross-sectional, multicenter study took place in Quebec City (Canada), Umeå (Sweden), and Diepenbeek (Belgium).

Participants
In total, 158 healthy individuals aged between 40 and 89 years, as well as 87 with COPD in a similar age span (51 to 88 years), participated in this study. Potential study participants were identified from respective local research databases and/or local advertisements. All study participants provided written informed consent. Exclusion criteria for healthy controls and people with COPD are seen in Table 2.

Table 2. Exclusion criteria.

Exclusion criteria	**HC**	**COPD**
Known chronic diseases that could affect muscle function such as ischemic heart disease, heart failure, respiratory disorders, any cancer, diabetes, neurologic or orthopedic conditions	Yes	Yes, with the exception of the presence of COPD (which was an inclusion criterion for this group)
Use of statins	Yes	Yes
Use of systemic corticosteroids (oral or injection) within three months of study procedures	Yes	Yes
Participation in high-level exercise program involving lower limb (regular physical activities and a normal exercise program are not a problem)	Yes	Yes
Health status	N/A	Stable, not involved in a rehabilitation program within six months of study start

Abbreviations: HC; Healthy Control, COPD; Chronic Obstructive Pulmonary Disease, N/A; Not applicable.

Of the 87 participants with COPD, 72 were recruited for another study initially (36) and 15 were specifically recruited for the present investigation. To be included, people with COPD needed to have a smoking exposure of at least ten pack-years and corresponding symptoms

in the presence of mild to very-severe airflow limitation confirmed via spirometry according to the GOLD classification (3).

Sample size
The study sample size was established to obtain a sufficient number of participants relative to the pre-specified number of covariates. Using a shrinkage factor of 0.98 and up to four covariates to build the statistical models, it was estimated that 139 participants were required. Considering a dropout rate of 10%, 158 control persons were enrolled.

Data collection
The study procedures were completed in a single visit for the healthy participants, and two visits for the participants with COPD with a minimum of 48h of rest between visits. After anthropometric measurements (body weight and height) and spirometry (127), quadriceps function was assessed as described below. In addition, functional exercise capacity was assessed by results on the six-minute walking distance (6MWD) and the one-minute sit-to-stand test (1STS) in people with COPD.

Isometric, isotonic, and isokinetic protocols
Different muscle properties of the quadriceps were evaluated on the dominant leg with a computerized dynamometer (System Pro 3 or 4, Biodex Medical Systems, Shirley, New York, NY, USA), using isometric, isotonic, and isokinetic protocols that have shown their reliability and feasibility in people with COPD (31, 128).

- *Isometric strength (Strength$_{ISOM}$)* was measured via five maximum voluntary isometric contractions (MVC) sustained for five seconds, with one minute of rest between contractions. The evaluator provided standard verbal instructions and strong encouragement. Quadriceps MVC torque was recorded in Newton-meters (Nm) for each contraction, with Strength$_{ISOM}$ defined as the mean of the two highest reproducible MVCs (i.e., <10% difference in peak MVC torque).

After the Strength$_{ISOM}$ test, which was always conducted first, the endurance tests described below were performed in a randomized order with a 30 min rest between tests.

- Isometric endurance (Endurance$_{ISOM}$) was evaluated during an isometric contraction performed at 60% of the individual's MVC and the participant was instructed to keep a maintained

contraction between 55 and 65% of MVC using visual feedback (i.e., lines on the computer screen of which the maintained between). The test ended when the applied force fell below 50% MVC for three consecutive seconds. The evaluator gave standard verbal instructions before the test, but no verbal encouragement was given throughout the test.

- Isotonic endurance ($Endurance_{ISOT}$) was measured by performing a maximal number of quadriceps contractions at 30% of MVC until exhaustion throughout the full pre-set range of motion and at an imposed tempo of 60 beats-per-min. A visual marker was used to indicate when the extension could be considered complete. The evaluator gave standard verbal instructions before the test, but no verbal encouragement was given throughout the test. The test was stopped when the person could not sustain the accurate tempo or when the range of motion was not reached for three consecutive repetitions. $Endurance_{ISOT}$ was defined as the number of repetitions performed multiplied by the load applied.

- Isokinetic endurance ($Endurance_{ISOK}$) protocol consisted of 30 consecutive maximal knee extensions throughout the full pre-set range of motion at an angular velocity of 90° per second. The evaluator gave standard verbal instructions and strong verbal encouragement throughout the test. Total work (Joule, J) was defined as $Endurance_{ISOK}$.

    - Isokinetic power ($Power_{ISOK}$) was the average power (Watt, W) obtained from the 30-repetition $Endurance_{ISOK}$ test

Notably, the endurance tests were designed with the goal to last approximately 1-minute so that the tests would measure a similar type of endurance. As an example, the $Endurance_{ISOK}$ took exactly 1 minute to perform with 30 repetitions with an angular velocity of 90° per second while the % of $Strength_{ISOM}$ MVC selected for the $Endurance_{ISOT}$ (30% of MVC) and the $Endurance_{ISOM}$ (60% of MVC) was based on previous literature and pilot testing to achieve this goal. In previous work by our group examining the reliability of these tests, it was found that the $Strength_{ISOM}$ test took 47 to 50 seconds to complete, and the $Endurance_{ISOT}$ 56 to 58 seconds (31).

Functional exercise capacity

Functional exercise capacity was assessed for the participants with COPD only, using the 6MWD and the 1STS. The 6MWD was performed

according to the *European Respiratory Society/American Thoracic Society* standards (31). Standardized instructions and encouragement were given to the persons with COPD, who were asked to walk as far as possible for 6 minutes on a 30 meters walking course. Two tests were performed, and the longest distance walked was used for the analyses. The 1STS was performed according to the recommended procedures on a standardized 48-cm-high chair without armrests and stabilized against a wall following standardized instructions (32). The person was asked to stand up from a sitting position as many times as possible in one minute. The number of repetitions performed was used for the analyses.

Analysis

Paper I and Paper II

Since the data (from semi-structured interviews) used in **Paper I** and **Paper II** were already generated, and the goal was to explore experiences of using an eHealth tool, analysis was made using qualitative content analysis (QCA). QCA is useful when dealing with already existing material and for making sense of experiences of a process (129). It uses a step-by-step, systematic analysis and a process of interpretation which looks especially at differences and similarities within the data. Finally the data are organized into subcategories, categories, and sometimes themes. QCA is recognized as a fitting method for examining people's experiences of an intricate phenomenon in a systematic way (116).

Paper I

The analytic process started with reading through the interview material several times, using the audio recordings to broaden the understanding of the data. This was followed by condensing, coding, and sorting the material into subcategories and categories (116). Using the software MAXQDA 2018 was helpful when keeping track of the different interviews, codes, and quotes. Investigator triangulation was used in all stages of the analytic process to reach a higher level of credibility (99, 116). During the triangulation, two co-authors coded one to two interviews and discussed their codes with the main author to reach a consensus about what was seen in the material. Also, during the interviewing phase, the authors continuously discussed the material while using a semi-structured interview guide, as a means to enhance dependability (116).

While analyzing it became clear that people with COPD had used the eHealth tool in varying amounts, and a new question arose: does the amount of time spent with the tool have anything to do with what they are expressing regarding using it? (Time spent using the tool was only measured during the initial 3 months, after that the data was unknown). So, after all coding was complete and some clustering had taken place, the time spent with the tool was explored and a cut-off was created – dividing the individuals of the study into two groups: "Users" and "Non-/seldom users". If they had more than 1 login/month or more than 20 minutes total spent time/month at the 3-month follow-up, they were defined as a

"User", and if they did not meet these criteria, they were instead defined as a "non-/seldom user".

Using this definition, the codes within the subcategories were marked with which group (or groups) had experienced it. Additionally, an individual's responses on two different occasions (3 and 12 months respectively) were studied whenever they took part in both.

Paper II

First, interviews were read through several times (with the assistance of audio recordings for auditory cues). Next, the transcript content was divided into meaning units consisting of constellations of words and statements with the same meanings. The meaning units were then condensed and coded using Open code software 4.03 [35] by one co-author, with independent parallel coding made by two other co-authors in two interviews. Based on similarities and differences between codes, preliminary subcategories were clustered, abstracted, and merged into categories. The interpretive process was made in several steps and the analytical process involved a back-and-forth movement between the whole and parts of the texts. Through the analysis process, triangulation between researchers with different backgrounds was used to attain higher credibility [33]. All authors were involved in creating subcategories and categories, and changes were made until consensus was achieved. Trustworthiness was sought, for example, by all co-authors' participation in several steps of the analysis, and the authors' complementary competencies and perspectives were of great importance in the analysis. In **Paper II**, all authors were physiotherapists but otherwise had various expertise and experiences. The group had access to clinical expertise in COPD, specialist competence in COPD and exercise training, and scientific expertise in COPD, in eHealth, exercise training/rehabilitation, and in qualitative research. During the discussions, the researchers critically reflected upon their prior understanding.

Paper III

Data were analyzed using Constructivist Grounded Theory (CGT) method since this method is apt when the goal is to study how and why participants make specific actions/choices in a particular situation (125). The CGT method recognizes that the resulting theory is an interpretation, a CGT theory is related to the researcher/s developing it and it is not meant to "stand alone" outside of that context. According to Silverman (130), one can only understand why people do as they do after figuring out how they construct meanings and actions, meaning that the *why* might appear with the *how*. The CGT is an iterative process where memoing, data generation, coding, analyzing, and theorizing (etc.) are constructed in a back-and-forth kind of manner, where new questions arise and are investigated as the research goes on (125).

The interviews were conducted by the main author, and transcription was made separately by the interviewer and a professional third-party transcriber, verbatim. Transcripts were proofread by the interviewer, who subsequently utilized them together with field notes and audio recordings to get to know the material. This helped provide learning lessons for upcoming interviews and for analyzing the data. Some minor revision of questions and formulation of questions was done depending on what was seen in the material as the analysis went on. Transcriptions were not shared with the participating individuals for any feedback.

The software used for facilitating data management was MAXQDA 2020. The interviewer coded and analyzed the content in collaboration with co-authors. Initial coding (segment by segment) was followed by a low-level abstraction. Clustering was used to highlight patterns and make the data easier to manage. Thereafter, axial and conceptual coding was weaved together resulting in some rearranging and structuring within the clusters. After all this, the three interviews from the theoretical sampling phase were recorded, transcribed, and analyzed by the interviewer in the same way as the previous material. All coding, clustering, subcategorizing, and categorizing were executed in an iterative manner and revisited through the analysis. Finally, all categories/themes were constructed inductively from the data.

Memos were written throughout the process and were used as a way to clarify the thoughts and findings, as well as to simplify communication with co-authors (as they help in verbalizing thoughts and more abstract patterns). Discussions among the researchers in the group have been

ongoing throughout the process, from the development of the interview guide to the final results. During the theoretical sampling phase, all three interviews were recorded, transcribed, and analyzed by the interviewer.

Paper IV

Data were analyzed using linear regression and Pearson correlations, which is a measure of linear correlation between two sets of data.

Multiple linear regression analyses were performed to establish reference equations in healthy persons, using $Strength_{ISOM}$, $Endurance_{ISOM}$, $Endurance_{ISOT}$, $Endurance_{ISOK,}$ and $Power_{ISOK}$ as dependent variables. As independent variables readily accessible participants' characteristics (age, sex, height, and BMI) were used. Separate regression analysis was done for each dependent variable. Descriptive data were expressed as mean ± standard deviation (SD) or frequency (proportion).

We checked continuous variables for the assumption of linearity using graphical representations and used the SAS function "R^2 selection method (RSQUARE)" to find the best subset of the participating person's characteristics including interaction terms. This then predicted the dependent variables. The RSQUARE function was also utilized for selecting the model with the lowest Akaike information criterion (AIC), for each dependent variable. To assess the fit and adequacy of the models, model fit statistics and diagnostic statistics were used. If collinearity was present between two independent variables, the variable that correlated best with the dependent variable was kept. We verified the normality assumption with the Shapiro-Wilk tests on the error distribution from the statistical models.

As a primary threshold to assess the presence of reduced quadriceps strength, endurance, and power in people with COPD, the lower limit of normal (LLN) at the 5^{th} percentile was used (2,25) and calculated according to the method previously published by Trethewey et al. (25). For comparative purposes with previous research, we also calculated the proportion of people with COPD whose measures of quadriceps properties were <80% predicted. Pearson correlations were used to evaluate associations between muscle properties values and functional exercise capacity results in people with COPD to determine the construct validity of the reference equations. A p-value of <0.05 was considered statistically significant and all statistical analyses were performed using SAS v9.4 (SAS Institute Inc., Cary, NC, USA) and GraphPad version 9.3.1 (GraphPad Software, San Diego, CA, USA).

Ethical considerations

The studies included in this thesis were conducted according to the World Medical Association´s Declaration of Helsinki's ethical principles for conducting research and approved by respective local ethical boards across the studies. Before enrollment in all studies, written informed consent was obtained from each participant.

Paper I & II: Ethical approval was given by the Regional Ethical Board, Umeå University, Umeå, Sweden (Dnr: 2014-319-31, 2015-457-32)

Paper III: Ethical approval was given by the Regional Ethical Board, Umeå University, Umeå, Sweden (Dnr: 2018-274-31 plus amendment Dnr: 2019-05572).

Paper IV: Ethical approval was given by the respective local ethics committee (Umeå, Sweden: Dnr: 2015/426-31, 2020-06881; Québec, Canada: CÉR 21785; Diepenbeek, Belgium: B9115201941687X).

The ethical concerns across the studies were few but always when dealing with, e.g., interviews (**Papers I-III**) there are risks of making the interviewee uncomfortable and/or making them aware of something that might harm or traumatize them. This could, for example, be highlighting a cover up-strategy that they are not aware of, thus uncovering an issue that is traumatic for them to uncover, leaving the interviewee with a traumatic insight without helping them cope with it (as you would in a health care setting). An interviewee might also be expecting the interview to be part of a health care intervention, thus getting frustrated, sad, or feeling ignored when the interviewer isn't helping them with their problems or questions but instead merely making a note of them. To counteract these risks, the interviewer of **Paper III** informed each interviewee extensively about the goal of the interview and also gave space for questions at the end of the interview. The interviewers of **Papers I-II** also informed each interviewee about the goals of the interview. Regarding **Paper IV**, there is always a risk of exposing the participants to injury or illness when testing muscle function and functional capacity in a lab setting. We have tried to counteract this by making sure that the individual is comfortable throughout the testing scenario and, mainly due to COVID-19, being cautious about hygiene and signs of illness in ourselves and our participants so as not to spread diseases.

Results

Paper I[2]

A controlled pragmatic pilot trial was conducted in which individual interviews were performed with a sample of people with COPD that had access to an eHealth tool (the COPD Web) as part of a process evaluation and thereafter analyzed using qualitative content analysis. Additionally, as mentioned in the methods section, to further explore usage over time, the persons with COPD were sub-grouped based on their objective use of the COPD Web during the initial 3 months, into *user* or *non-/seldom user*. An explanation and description of the sub-groups can be seen in Box 2.

The analysis resulted in 3 main categories "*Ambiguous impact*", "*Basic conditions for usage*" and "*Approaching capability*" which, together with the subcategories, represent the overall experiences of the persons with COPD regarding the use of the COPD Web over time.

Box 2. Brief explanation/description of sub-groups.

Of the 16 participants in the interviews **at 3 months**, there were **six *users*** and **10 *non-/seldom users***. (Users had in median (range) 10 (5-22) logins and spent 43 (27 to 145) minutes on the COPD Web, in contrast, *nonuser/seldom users* had 1.5 (0-14) logins and spent 1.8 (0-16) minutes on the site.) **No apparent differences between *users* and *non-/seldom users*** were seen regarding characteristics such as age, sex, lung function, stage of COPD, smoking status, employment status, living conditions, or education level. **However, *users* had**, on median, **sufficient communicative and critical health literacy while *non-/seldom users* had problematic communicative and critical health literacy**. Of those who accepted an interview at 12 months, 5 out of 7 were users at 3 months.

An overview of the findings is seen in Figure 8, indicating that the level of motivation, comfortability with IT tools, and the level of health literacy seem to affect the usage of an eHealth tool over time. Additionally, gaining benefits from the eHealth tool seems reserved for the *users* and specifically after 12 months, thus suggesting that eHealth tools such as the

[2] The **aim** of paper I was to explore and describe the experiences of people with COPD regarding using an eHealth tool over time and factors that might affect usage.

COPD Web can be suitable media for supporting COPD-specific self-management skills, although not for everyone and not always.

Figure 8. Overview of user experience and factors affecting usage. "Users at three months" represent experiences mainly seen among those who used the COPD Web during the initial three months. "Non-user/seldom-users at three months" represent experiences mainly seen among those who did not use, or used to a limited extent, the COPD Web during the initial three months. "Users and non-user/seldom-users at three months" represents experiences seen among both users and non-user/seldom-users at three months while "12

months" represents experiences mainly expressed at 12 months. *Based on the communicative and critical health literacy scale, Swedish version (131).

Ambiguous impact

This category consisted of four subcategories (presented with subheadings below), and persons with COPD were expressing contradicting thoughts about seeking information about COPD, and health care due to the disease. Also, different thinking regarding competence and motivation when talking about using information technology (IT) was heard here.

Shame influencing use

Participating persons expressed sometimes experiencing their diagnosis as something taboo or embarrassing, leading to isolation. In turn, this lead non-/seldom users to *not use* the eHealth tool and the users to *try it out*. It was for the latter group a way to counteract the feeling of not having anyone to talk to about their disease. Shame and guilt regarding smoking (in relation to having COPD) could hinder non-/seldom users from telling close ones about their COPD, as well as from seeking health care. Getting COPD was seen as their own fault, and so the eHealth tool could be viewed as undeserved assistance.

Knowledge about disease and self-management is two-faced

People with COPD voiced curiosity about new information and had often at some point actively looked for information. However, while users saw the gain of accessing loads of information, non-/seldom users were hesitant, saying that information could be intimidating (especially when questioning your preconceptions). At 12 months, people with COPD expressed usually revisiting the eHealth tool to either find out if new information had been published or to refresh their memory on something.

Health status as motivator or excuse?

Health status was voiced as a reason for visiting or not visiting the eHealth tool. While some said that feeling too well was a reason for *not* needing or wanting to use the tool, for others feeling well was *needed* to be able to take in new information. At 12 months, former users still thought it more likely that they would use the tool if they were feeling less well.

IT-comfortable or not?

Users regarded themselves as relatively comfortable using computers and the internet. Non-/seldom users expressed dislike and inexperience towards computers or the internet as obstructions for using the eHealth

tool or otherwise generally searching for information. Not prioritizing, having an interest in, or time for, computer or eHealth tool use, and preferring to read information on a paper instead of on a screen were also voiced by non-/seldom users. At 12 months, disinterest in the eHealth tool was mentioned as a cause for not using it. Health professionals or close relatives were also needed as support for using technology, for motivational purposes, and for allocating time for computer use by non-/seldom users.

Basic conditions for usage

This category includes four subcategories (see subheadings below) touching on technical aspects of the eHealth tool.

Levels of eHealth accessibility
The concept, layout, and functionality of the eHealth tool were generally appreciated throughout both follow-up-occasions. Technical issues were described as frustrating and inconvenient, and among non-/seldom users, the COPD Web's low compatibility with smartphones was reported as a hindrance at both 3 and 12 months.

Triggers: carrot or stick?
The triggers (i.e. automated notifications of new content, pedometer, and step registration function) was generally seen as a facilitator by the participating persons with COPD. They were, overall, seen as helpful and motivating. However, the pedometer was also recognized as a possible source of stress if they felt they had not done enough physical activity. By and large, the introduction, by health professionals, to the COPD Web helped spark an interest in the tool, according to people with COPD. Non-/seldom users expressed a feeling of getting valuable support during the introduction, making them inclined to participate despite feeling insecure about computer use. Further, some users expressed participating due to a sense of duty. However, a somewhat contradictory experience was also conveyed, expressing that the introduction took too much time and felt irrelevant.

Feeling positive about the COPD Web
Users expressed a feeling of generally missing feedback from the health care provider/system regarding the self-care they already did and were happy to be able to verify these using the eHealth tool. Among users, the possible prevention of health decline was voiced as a reason for using the tool. This group also felt positive about being able to choose what to focus on or do on the eHealth tool. They appreciated being able to remind

themselves about information, exercises, and other supportive tools for self-management. Both users and non-/seldom users regarded the eHealth tool as a source of positive external motivation, as well as voicing curiosity and positive anticipatory feelings towards it. The COPD Web was described as a new concept that had not been introduced to them before and which spiked their interest.

Irrelevant Tool
Non-/seldom users reported not having time for, or forgotten about, the eHealth tool, and some users also expressed this. A feeling of already having heard all the information since having lived with COPD for a long time was mentioned at both 3 and 12-month follow-up interviews. While some felt this was fine, some expressed frustration about not finding any new information. Ultimately, however, this seemed like a reason not to use the tool. Others felt they were already doing the self-care that the tool advertised and thus had no need for it. People with COPD, therefore, expected the eHealth tool to feel more relevant for the newly diagnosed.

Approaching capability

This category includes three subcategories (see subheadings below) and focuses on experiences regarding accessing COPD-specific knowledge and skills for self-management, experienced benefits from using the eHealth tool, and actual behavioral changes within 12 months of accessing the tool.

Know-how gives hope
People with COPD perceived the content of the eHealth tool as instructive in a concrete way, leading to new and satisfying knowledge and insights regarding self-care. Users used the website to search for information and advice, some saw it as positive to have access to all this information – seemingly regardless of how much it was used. Persons with COPD regarded the tool as helpful when changing habits since they could revisit it many times, and users felt more hopeful about their COPD after getting more information on what they could do (self-care). There were, however, users voicing the feeling of not at all changing their view on COPD from accessing the eHealth tool.

Starting to see the benefits
Affirming already acquired knowledge could be seen as a positive side effect of using the eHealth tool. Users also talked about visiting the website to learn more about COPD, the body, treatments, and certain exercises, in order to better their overall situation. In addition, the step

registration feature was regarded as a strong motivator for doing exercises.

Impact with more time

Within this subcategory, all statements are from the 12-month follow-up and persons with COPD reported that the eHealth tool had led to a better realization regarding the diagnosis, self-care strategies, and essential changes in everyday life. The tool helped bring understanding about key actions such as seeking care in time, but also in feeling more confident in the expertise one holds about one's own body. Other experiences focused on the actively changed patterns of body motions (e.g., standing up without using the hands), using the stairs more, and avoiding getting minor illnesses. Some reported having learned more from the eHealth tool than from traditional health care. Being reminded of various exercises and breathing exercises was described as a way to calm down, to feel more at ease. However, there were also persons with COPD (both former users and non-/seldom users) who still felt that their habits had not changed and that things were as they always had been—with or without the eHealth tool.

Paper II[3]

A controlled pragmatic pilot trial was conducted in which individual interviews were performed with HCPs that had access to an eHealth tool as part of a process evaluation and after that analyzed using qualitative content analysis.

Ten HCPs participated in the interviews at three months (and five at 12 months), including five nurses, two physiotherapists, one dietician, one occupational therapist and, one physician. They had 25 ± 11 years of work experience. The analysis resulted in three main categories "*Receiving competence support and adjusting practice*", "*Improving the quality of care", and "Efforts required for implementation*" (Figure 9).

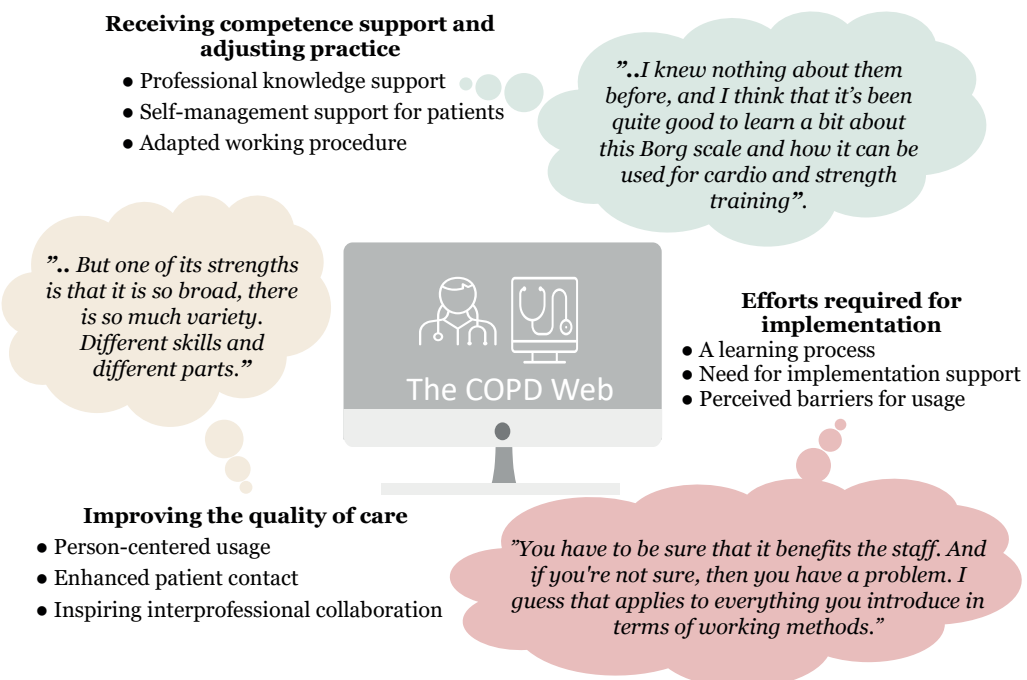

Figure 9. Overview of the main findings. Categories and subcategories, including examples of quotes.

[3] The **aim** of paper II was to explore the experiences of using an eHealth tool among HCPs that worked with people with COPD in daily clinical practice.

Receiving competence support and adjusting practice

This category included three subcategories (presented with subheadings below). It focused on how the COPD Web contributed to competence support for HCPs and people with COPD, and how the work was modified accordingly.

Professional knowledge support
HCPs expressed that the eHealth tool contributed with a pedagogical and more comprehensive toolbox, which could aid in meetings with persons with COPD - as well as in teaching them about their disease. It was seen as a well-comprised knowledge bank, updated and built on evidence, especially helpful as support for HCPs helping persons with COPD in areas outside of their own professional expertise. The tool was appreciated for making both them and persons with COPD more knowledgeable about COPD, physical activity, and exercise. The HCPs also considered the eHealth tool more illustrative and spontaneous than, e.g., brochures, helpful when prescribing physical activity, and when using various assessment tools.

Self-management support for patients
The HCPs expressed that the eHealth tool helped them reach people with COPD about self-care in a way that gave more response than before. The tool was perceived to contain excellent self-management support for them. Further, HCPs reported that interest in the eHealth tool varied among individuals with COPD and that those that were younger or more affected by their COPD used the tool more. HCPs also stated that persons with COPD that used the eHealth tool had more time to learn new things through using it and, therefore, sometimes asked more questions during appointments. The HCPs further stated that these persons with COPD adhered better to their treatment interventions.

Additionally, according to the HCPs, people with COPD that had access to the eHealth tool had expressed a better understanding of COPD, an acceptance of living with it, lower anxiety about the disease progression, increased motivation to do physical activity, and improvements in physical function. These were expressed as positive consequences of using the eHealth tool.

Adapted working procedure
HCPs felt that the eHealth tool was logical, easy to navigate, adaptable to the needs of people with COPD, provided structure for appointments, and helpful for patient education classes. The HCPs talked about reflecting on

the content together with the person with COPD and being helped by videos as they aided communication.

Using assessments of physical function and finding suitable physical activities and training for people with COPD was perceived as easier due to the eHealth tool, stated the HCPs. The eHealth tool was also used to prepare for patient consultations, as some HCPs asked their visitor to fill out “my COPD profile”, amongst other things, beforehand. This was experienced as a help to better meet the needs of the person with COPD at the time of the appointment, as reported by HCPs.

While some HCPs stated a solid wish to continue using the eHealth tool in the future, some felt that the tool had not affected their way of working with persons with COPD. At the 12-month interview, HCPs also said that they worked less with the eHealth tool, and less structured, compared to the initial months.

Improving the quality of care

This category consisted of three subcategories (see subheadings below) and discussed the importance of person-centered usage, as well as the added value and improved care when using the eHealth tool.

Person-centered usage
The HCPs described that persons with COPD of varying ages and disease stages recognized themselves in different information on the eHealth tool, and that they as HCPs had to choose what content to present to provide person-centered care. A wish for an even more diverse information base regarding the disease at different stages and severity was expressed by the HCPs. The individually tailored patient meetings were seen as crucial when motivating to self-management among people with COPD. Lastly, the HCPs also felt that nutrition and emotional support were not covered adequately by the eHealth tool.

Enhanced patient contact
Using the eHealth tool was described, by the HCPs, as initially lengthening the patient counseling time but simultaneously enhancing the quality. This, stated the HCPs, gave them a feeling of well-invested time for future healthier people with COPD. They also pointed out that conveying information must be allowed to take time.

When using the eHealth tool, according to the HCPs, work had become more preventive and thus had resulted in fewer emergency visits for

people with COPD at the health care centers. The eHealth tool was also considered to facilitate telephone counseling, which led to telephone follow-ups replacing physical visits and, therefore, saving time. HCPs were convinced this was a beneficial and safe alternative for people with COPD. Consequently, HCPs voiced a wish to reintroduce annual visits for people with COPD that were not prioritized at present due to lack of time.

Inspiring interprofessional collaboration
The HCPs stated that the eHealth tool could contribute to collegial and interprofessional collaboration and that they had increased contact with other HCPs working with COPD. Interprofessional collaboration was considered important, and participants described using different parts of the eHealth tool when talking to people with COPD, depending on their profession. However, the HCPs expressed that content of the eHealth tool highlighted the physiotherapist's key role in COPD management and that they (physiotherapists) needed to take a more significant part in COPD management in the future. Additionally, HCPs stated the vital role of occupational therapists regarding COPD management, preferring that they should be involved more. The eHealth tool was suggested to additionally be used in hospital care, home care, and group treatments for COPD, as well as even being considered helpful for other patient groups – such as for people with heart failure.

Efforts required for implementation

This category includes three subcategories (as presented in subheadings below) and focuses on the process of learning to use the eHealth tool, matters they found necessary for implementing it, and barriers to using the tool.

A learning process
Familiarizing oneself with the eHealth tool took time, and more time and information initially (on how to use it) was expressed as desirable by the HCPs. Especially getting to know the parts they wanted to show people with COPD was required. There was a need for the tool to function well, and not be too complicated to navigate. Delays when starting videos, or videos that were too long, could disrupt the patient meeting, according to the HCPs. At 12 months, those that used the tool experienced that it had become more integrated into their daily work.

Need for implementation support
Regarding implementing new eHealth tools: changing routines and learning new ways takes time and could be associated with resistance.

Plus, the tool needs to show that it benefits both persons with COPD and health care providers, stated the HCPs. Additionally, when implementing this kind of eHealth tool, support from management was considered vital, and support from colleagues was seen as very important. Further, introduction and education on usage need to be useful, and practical training offered. Lastly, HCPs emphasized the importance of role models – seeing centers/health care providers that already use the tool and have a positive experience.

Perceived barriers for usage

Among mentioned needs for getting started with the eHealth tool was a pre-anchored work procedure, feeling involved in the decision-making, access to a computer in the consulting room, and enough time to do/prioritize the new way of working. People with COPD needed not to be too sick, to have a computer at home, and to have enough computer skills in order to get the largest gains from the eHealth tool, according to the HCPs. They stated that the eHealth tool needed to feel like a natural part of the patient visit to be used.

Paper III[4]

A pragmatic RCT was conducted in which individual interviews were performed with a sample of people with COPD that had access to an eHealth tool, the COPD Web, over a 12-month period. CGT analysis was used. In total, 15 individuals participated in the interviews, 13 in the first round of interviews and three (one new) in the second round.

The analysis resulted in the three main categories "*Welcoming or not welcoming action*", "*Having or lacking resources*" and "*Lowering the threshold*". The first two showed both facilitators and barriers, while the last one only expressed facilitators within the setting (Figure 10, next page). The categories lead to the more latent theme of "*Perceiving enough control to enable action*". This theme suggests that having or perceiving a certain amount of control would be key to maintaining or increasing the level of physical activity when one has COPD and uses an eHealth tool.

Welcoming or not welcoming action

As previously stated, within this category people with COPD voiced facilitators as well as barriers related to physical activity and information technology (IT). Statements in this category are interpreted as expressions of the Fogg Behavior Model's (FBM) motivation-focused part (132). For example, persons with COPD expressed feelings of positive, negative, or absent effects from doing or planning to do physical activity (representing the existence or absence of motivational factors according to the FBM).

Facilitators
People with COPD expressed positive emotions and bodily sensations from physical activity, and/or PA-related environment and context, including reaching goals and having positive memories. Further, an interest, desire, or belief in physical activity was described here. This was also mentioned regarding IT in general, which was portrayed as unproblematic and exciting, and the eHealth tool in particular, which was recounted as supportive, reassuring, instructive, useful, and could make one feel heard/respected. In other words, the eHealth tool was interpreted as a motivational factor regarding increasing or maintaining a certain level of physical activity.

[4] The **aim** of paper III was to identify enablers and barriers for the use of web-based support with the COPD Web in order to change behavior.

Barriers
Here, lacking subjectively meaningful incentives to act was described, such as the feeling of physical activity being tedious, not for them (however beneficial for others), or high enough on their priority list for whatever reason. Feeling plainly satisfied with the current level of physical activity, for example. Also expressed was a lack of incentives regarding using IT and/or performing information searches (including COPD-specific searches).

Subcategories	Categories	Theme
Feeling happy about physical activity	Welcoming or not welcoming action	Perceiving enough control to enable action
Feeling happy about using an eHealth tool		
Lacking adequate incentives to act		
Managing the situation well	Having or lacking resources	
Wanting for outside support to create ableness		
Identifying as incapable to act		
Using the environment /context as help to engage in physical activity	Lowering the threshold	

Figure 10: Category tree, from subcategories to theme, left to right.

Having or lacking resources

Again, both facilitators and barriers were described by persons with COPD in this category, and the content was interpreted to highlight ability-related factors, according to the FBM (132), as key for agency/taking action. These ability-related factors, read in the data, included self-efficacy (the belief in one's own capacity to act in the ways needed to reach a certain goal), social support, time, equipment, incentives/motivational factors, mental and/or physical ability, experiences, etc. Namely, anything that affects your ability to execute a desirable action.

Facilitators
Feelings of agency, ableness, hopefulness, inspiration, having enough time, being able to challenge oneself, and adaptability to new situations were described here. Additionally, acting out of a sense of duty, being a persistent person, and having successfully managed a behavior change or an improvement/preservation of one's health status before in life, were also interpreted as facilitators in this setting.

Barriers
Feeling socially or medically unsupported, or experiencing a lack of resources to change behavior, as well as unhelpful contextual factors, were voiced as obstructing with regard to physical activity and using an eHealth tool. Feeling distrusting or unsure about IT use were also considered obstructions to ability within the setting. In addition, shame, negative self-image, stress, fear, hopelessness, fatigue, struggle to adapt to new situations, and losing momentum was identified as hindrances to feeling able. Lastly, injury or illness was, of course, part of the obstructions of behavior change experienced by people with COPD.

Lowering the threshold

Within this last category persons with COPD only expressed facilitators for doing physical activity, and the category was interpreted as highlighting trigger-related factors following the FBM (132). They described feeling supported by exercise groups, health care, and the eHealth tool. Things, people, pets, or events were recounted as pushing persons with COPD into action (in a helpful way). Additionally, doing housework, following a routine, or engaging in a hobby, or a seasonal activity, that was physically demanding was depicted as helpful as it made it easier to take action (i.e., in this case, be physically active).

Paper IV[5]

Participants

In total, 158 healthy persons (67 in Quebec City, 68 in Umeå, and 23 in Diepenbeek) and 87 people with COPD (54 in Quebec City and 33 in Umeå) were included. Compared with the healthy control group, the group with COPD was older and had worse lung function (see Table 3).

Table 3. Participant characteristics, both healthy and COPD-population.

Characteristics	Healthy, n=158	COPD, n=87	p
Age, y	62 ± 12	69 ± 7	<0.0001
Female, n (%)	83 (53)	34 (39)	-
Height, m	1.69 ± 0.08	1.67 ± 0.09	0.05
Weight, kg	74.4 ± 14.7	75.5 ± 16.5	0.06
BMI, kg/m²	25.8 ± 4.0	26.9 ± 4.6	0.07
FVC, % of predicted	114 ± 15	98 ± 21	<0.0001
FEV_1, % of predicted	108 ± 14	59 ± 20	<0.0001
FEV_1/FVC, %	77 ± 5	47 ± 12	<0.0001
GOLD (I/II/III/IV), n	N/A	16/42/18/ 11	N/A
Quadriceps property			
$Strength_{ISOM}$, Nm	169.0 ± 58.7	138.5 ± 47.8	<0.0001
$Endurance_{ISOM}$, s	58 ± 27	49 ± 22	0.005
$Endurance_{ISOT}$, Nm*reps	1922 ± 1503	1014 ± 550	<0.0001
$Endurance_{ISOK}$, J	2543.2 ± 812.4	1928.3 ± 746.0	<0.0001
$Power_{ISOK}$, W	86.9 ± 29.1	59.7 ± 21.5	<0.0001
Functional exercise capacity			
6MWD, m	N/A	473 ± 115	N/A
1STS, reps	N/A	23 ± 7	N/A

Abbreviations: BMI; Body mass index, FVC; Forced vital capacity, FEV_1; Forced expiratory volume in the first second, GOLD; Global Initiative for Chronic Obstructive Lung Disease, $Strength_{ISOM}$; Quadriceps isometric strength, $Endurance_{ISOT;}$ Quadriceps isotonic endurance, $Endurance_{ISOK;}$ Quadriceps isokinetic endurance, $Power_{ISOK;}$ Quadriceps isokinetic power, 6MWD; 6-minute walking distance, STS; sit to stand, reps; repetitions, N m: Newton meter, s; seconds, J; joules, W; watt, N/A: not applicable, n; population, y; years, m; meters, kg; kilograms, m²; square meters.

[5] The **aims** of paper IV were to 1) develop reference equations to obtain predicted values for quadriceps strength, endurance, and power in healthy individuals, 2) test the reference equations in people with COPD to establish the prevalence rate of reduced muscle strength, endurance and power in this population and, 3) explore the construct validity of the proposed equations by documenting evaluating the relationships between quadriceps function and functional capacity in people with COPD.

Reference equations

Suggested models using age, sex, height, and BMI as independent variables explained 69% ($Strength_{ISOM}$), 5% ($Endurance_{ISOM}$), 48% ($Endurance_{ISOT}$), 71% ($Endurance_{ISOK}$), and 69% ($Power_{ISOK}$) of the variance in the variables respectively. Considering that $Endurance_{ISOM}$ could not be reliably predicted, it was excluded from further analysis.

- **$Strength_{ISOM}$, Nm**. Y= -982.2 + 12.6(age) - 50.5(sex) + 742.7(height) + 1.6(BMI) - 8.6(age*height), **adjusted R^2 = 0.69**, p<0.0001, SEE = 32.16
- **$Endurance_{ISOM}$, s.** Y= 92.6 + 0.3(age) - 23.1(sex) - 2.0(BMI) - 0.8(age*sex) + 2.8(sex*BMI), **adjusted R^2 = 0.05**, p=0.03, SEE=NA
- **$Endurance_{ISOT}$, Nm*reps.** Y= e(5.13 - 0.01(age) - 0.42(sex) + 1.86(height)), **adjusted R^2 = 0.48**, p<0.0001, SEE = 0.38
- **$Endurance_{ISOK}$, J.** Y= -454.6 - 43.9(age) - 1931.7(sex) + 3256.4(height) + 20.1(BMI) + 21.8(age*sex), **adjusted R^2 =0.71**, p<0.0001, SEE = 433.43
- **$Power_{ISOK}$, W.** Y= -3.3 - 1.6(age) - 71.1(sex) + 103.5(height) + 1.0(BMI) + 0.8(age*sex), **adjusted R^2 = 0.69**, p<0.0001, SEE = 16.11

Prevalence rates of reduced muscle function

All quadriceps properties ($Strength_{ISOM}$, $Endurance_{ISOM}$, EnduranceISOT, $Endurance_{ISOK}$, and $Power_{ISOK}$) were lower in people with COPD compared to healthy participants (p<0.05).

Prevalence rates of reduced muscle function were expressed as the percentage of people below the lower limit of normal (LLN) and <80% predicted value, two commonly used thresholds. Independent of threshold, $Endurance_{ISOT}$ was the muscle property in people with COPD that had deteriorated the most, compared to the group of healthy individuals, ranging from 43% (LLN) to 80% (<80% predicted value).

Table 4. The proportion of people with COPD that showed deteriorated muscle property when using either LLN or <80% of predicted value as a threshold for indicating reduced function.

Quadriceps property	LLN	<80% of pred.
$Strength_{ISOM}$, Nm	14	37
$Endurance_{ISOT}$, s	43	80
$Endurance_{ISOK}$, Nm	26	51
$Power_{ISOK}$, Nm	36	61

Abbreviations: LLN; Lower limit of normal, Pred: predicted, $Strength_{ISOM}$; Quadriceps isometric strength, $Endurance_{ISOT}$; Quadriceps isotonic endurance, $Endurance_{ISOK}$; Quadriceps isokinetic endurance, $Power_{ISOK}$; Quadriceps isokinetic power, N m: Newton meter, s; seconds.

Construct validity

Results of the correlation analyses between $Strength_{ISOM}$, $Endurance_{ISOT}$, $Endurance_{ISOK}$, and $Power_{ISOK}$ expressed in % of predicted values and functional exercise capacity in people with COPD are seen in Table 5.

In brief, $Strength_{ISOM}$, $Endurance_{ISOT}$, $Endurance_{ISOK}$, and $Power_{ISOK}$ predicted values were weakly to moderately correlated (r-value ranging from 0.28 to 0.49 [$p<0.05$]) with 6MWD and 1STS. Notably, $Endurance_{ISOT}$ was only correlated with the 1STS.

Table 5. Correlation analysis: Muscle properties and functional tests.

Quadriceps property	**6MWD, m**		**1STS, reps**	
	r	*p*-value	r	*p*-value
$Strength_{ISOM}$, Nm	0.37	0.0004	0.30	0.005
$Endurance_{ISOT}$, s	0.19	0.07	0.28	0.008
$Endurance_{ISOK}$, Nm	0.46	<0.0001	0.49	<0.0001
$Power_{ISOK}$, Nm	0.44	<0.0001	0.49	<0.0001

Abbreviations: $Strength_{ISOM}$; Quadriceps isometric strength, $Endurance_{ISOT}$; Quadriceps isotonic endurance, $Endurance_{ISOK}$; Quadriceps isokinetic endurance, $Power_{ISOK}$; Quadriceps isokinetic power, BMI; Body mass index, r; Pearson's correlation coefficient.

Discussion

The aim of this thesis was two folded, firstly to examine (using qualitative analysis) the usability and potential benefit of an eHealth tool regarding COPD-specific disease management and physical activity, both short and long-term (**Papers I-III**). Secondly, (using statistical analysis and quantitative research methods) to develop reference values and equations for quadriceps muscle properties testing and to document their construct validity (**Paper IV**).

In summary, the findings of **Paper I** suggested that the level of motivation, IT-comfortability, and health literacy seemed to affect the usage, by persons with COPD, of an eHealth tool over time. Additionally, regarding behavior change, it seemed that using the eHealth tool – and letting time pass – was beneficial. This, in itself, suggested eHealth tools can be suitable support for COPD-specific self-management skills for people with COPD, even if they might not suit everyone, or at all times. The results of **Paper II** indicated that the use of an eHealth tool among health care professionals engaged in COPD management improved the quality of care and enabled competence support and clinical practice adjustment. However, the successful implementation of an eHealth tool also seemed to require some effort from both the workplace and employees. In **Paper III**, our results suggested that a person with COPD needed to experience some level of control over their situation/in life to perform physical activity and to use, and benefit from, an eHealth tool. Using the eHealth tool, however, appeared to be helpful for performing physical activity also in itself. Lastly, the results of **Paper IV** showed that, among healthy participants, age, sex, height, and BMI explained 50-70% of the variance in quadriceps strength, power, and endurance. In comparison to healthy controls, strength, power, and endurance properties of the quadriceps were reduced in 14-80% of the COPD population depending on the cut-off used and the muscle property examined. Additionally, the values obtained from the reference equations for quadriceps strength, endurance, and power correlated with commonly used functional tests of similar magnitude as previously reported from direct measures of these muscle properties (36). Thus, supporting the construct validity of the predictive values in people with COPD.

Interpretation of findings

The interpretation of findings section is structured to highlight the link, similarities, and dissimilarities across the papers within my thesis into four different sub-sections: *Adaptation/incorporation, contextual factors, autonomy/agency*, and *communication*. These sub-sections should not be interpreted as an extended analysis, but rather an attempt at structuring the thesis discussion and the links between the different papers.

The first section highlights where and how adaptation and incorporation can be seen in the different papers, as adaptation and incorporation has many similarities regarding taking in something new and working around it or even using it to benefit in the end. The second section lifts various contextual factors that might be of importance in managing COPD – both for the diagnosed individual and the health care professional. Autonomy or agency makes up the third section as a way of highlighting the focus in the papers on making decisions and acting for health benefits in various ways. Lastly, communication is the fourth section, lifting the possibilities of bettering or increasing the all-important communication within the health care system as well as between HCP and people with COPD.

Adaptation/incorporation

Adapting to or incorporating the needs of people with COPD begins with understanding the needs, and by using tests and clarifying what the results indicate, we can improve their treatment and care. Putting these working procedures into everyday practice means continuously learning and incorporating new knowledge for the HCPs. Being able to adapt to or incorporate new skills, habits, or working procedures was identified as important across all four papers within the current thesis. For example, in **Paper I,** where people with COPD seemed to be able to incorporate advice/knowledge from the eHealth tool into their everyday lives, and in **Paper II,** where HCPs needed to incorporate the eHealth tool into their everyday working life. These adaptations reportedly lead to a deeper use and benefit from the eHealth tool. In **Paper III** we saw that the incorporation of an eHealth tool among people with COPD in their daily life might give additional practical, emotional, and psychological help when aspiring to increase their physical activity levels. Lastly, as seen in **Paper IV**, the development of reference values and equations for the tests we do (in the clinical context) ascertain what treatment fits best for a specific individual. Thus, attaining reference values and equations and incorporating them to use can lead to an adaptation of the health care procedure and the care provided for persons with COPD.

Furthermore, our findings as well as others indicate that health literacy is crucial to be able to integrate health information/advice into your everyday context and to benefit from them (52, 132). Having a limited health literacy toward eHealth is (similar to our findings among people with COPD in **Paper I**) one of the most mentioned barriers to the implementation of eHealth services (133), which is in line with the interpretation of the importance of adaptation as a skill. However, in contradiction to earlier research by Schreiweis et al., wherein ease of use was identified as a key factor for implementing eHealth services (133), our findings state that both users and non-/seldom users found the tool easy to use. Further, also in **Paper I**, our findings indicate that even though technical difficulties are an annoyance, they do not have to determine the level of eHealth tool usage.

Additionally, in **Paper II**, we could also see that adaptation played a large part in including the eHealth tool in the HCPs' work situation. If one could adapt to a new way of handling the patient visit, preparing for it, and even making sure that persons with COPD could continue to use it after the meeting is over, then the eHealth tool would be of use and something to lean towards as a support system. According to our participating HCPs, the delivered knowledge support from the eHealth tool aided in adapting working procedures and communication. Among people with COPD, our findings in **Paper I** highlight that interest and curiosity about new information were repeatedly expressed among users of the eHealth tool, however, among the non-/seldom users, expressions of fear of new information were voiced. About the latter, Nguyen et al. (134) state in their research that fear of new information (as seen among those with problematic health literacy) negatively impacts, e.g., health-related quality of life, while having sufficient health literacy, and eHealth literacy has a positive impact. Does fear also have a negative impact on health literacy, and/or does health literacy have a positive impact on fear? Nguyen et al. seem to at least theorize that fear and (e-) health literacy can counteract each other with regards to, e.g., health-related quality of life. This, together with other research stating that fear can impede the learning process (135), could indicate that they could affect each other also. So, a question for future research could be: can a patient with COPD with fear of new information benefit extra from improving their health literacy?

Within **Paper III** we found that an eHealth solution might add some practical, emotional, and psychological assistance when trying to increase the level of physical activity. This means that the tool would help incorporate the steps needed for a behavior change resulting in more

physical activity. Other studies also support the interpretation that eHealth can be beneficial for increasing physical activity among people with COPD (107, 131, 136). For example, Vorrink et al. (107) suggested that eHealth tools could help increase the insight of people with COPD into their current physical activity level. This, in turn, could support a behavior change leading to increased physical activity (107). However, as highlighted in a recent systematic review, using eHealth interventions to promote physical activity for people with chronic respiratory diseases, although promising, remains an area where future investigations are warranted to identify optimal modalities and clarify the benefits (137).

Contextual factors

Contextual factors refer to environmental, physical, and/or psychological factors that impact an individual's ability to act. For example, as seen in my thesis, regardless of whether it is a person with COPD or an HCP, some conditions need to be met to enable the use of an eHealth tool. Time, for example, seemed important for all users in **Paper I** to learn and familiarize themselves with the tool. However, time also appeared to be of importance for us as researchers to evaluate the tool properly, as the effects of using the intervention were mainly seen after 12 months (rather than at the initial 3-month evaluation). If the user(s) weren't given enough time, it was suggested that there would be less success gained, i.e., users felt that time with the tool was needed for them to report positive effects on their situation. This seems to follow logically as more time might give you more opportunities to explore the tool and try things out in your everyday life. These findings are in line with the results from previous research suggesting that a continuous self-management program will aid people with COPD to perform certain self-health behaviors, thus implying that achieving changes in health behavior takes time (138). Within **Paper III** the eHealth tool was suggested to give users a heightened sense of control, and according to an earlier study, an increased sense of control is connected to an increased level of physical activity (139). However, the users of the eHealth tool within **Paper III** also seemed to need some amount of control in their life to use the eHealth tool in the first place.

Support and guidance were also highlighted as important for both people with COPD and HCPs, e.g., for learning to use the tool in a satisfactory way. Among people with COPD, this seemed to be mentioned more with those with a lower health literacy level. At the same time, among HCPs, similar to the research of Koivunen and Saranto (140), our findings indicate that inadequate support and lack of training are key hindrances to implementing and using eHealth tools. Regarding increasing one's

physical activity (as in **Paper III**), a social component was connected to the motivational level and might be needed to be met, and in addition to this, persons with COPD expressed experiences of feeling supported, being pushed into action, and being motivated when using the eHealth tool. Further, these individuals described being pushed into action, being motivated, and feeling supported when using the eHealth tool. This is in line with Vorrink et al. (107) discussing that eHealth tools be used to give persons with COPD insight into their current level of physical activity as well as receive support for increasing the physical activity level.

Accessibility was mentioned in both **Papers I** and **II**, in slightly different ways for people with COPD and HCPs. Both HCPs and persons with COPD mentioned that people with COPD needed access to a working computer and internet connection to be able to visit the eHealth tool. Preferably to have these at their home, however, regarding if they needed something printed, people with COPD mentioned asking their health care provider to help out. The HCPs also preferred to have access to a computer in the consulting room, to be able to make the eHealth tool a natural part of the consultation.

Related to these contextual factors was the know-how, and comfortability level, of using computers, the internet, and/or the eHealth tool. People with COPD, as well as HCPs, regarded too low levels of IT skills as a hindrance for using the eHealth tool, and the HCPs also noticed that it was impossible for them to tell (beforehand) which persons had sufficient skills or not. As mentioned before, learning how to use the tool was important for HCPs in order to make use of it in a treatment setting. This is in accordance with Koivunen and Sarantos research (140) where they found that adequate support and training were critical factors to a successful implementation of an eHealth tool among HCPs. Further support for this can be found in the research of Odendaal et al. (141), where the HCPs' needs for education, support, and training were the focal point for eHealth tools in a clinical setting (140, 141). Similar findings regarding the importance of education and training have been seen from HCPs engaged in COPD management (142-144)

Other contexts could affect usage too, according to the participants of the studies. The novelty of the diagnosis was, for example, suggested to affect the usage of the eHealth tool. This was in part according to the findings of Ansari et al. who saw that newly diagnosed individuals with COPD had difficulty in recognizing the impact of the disease on their health (due to low awareness of COPD and its long-term implications) (145). Another thing that we found was that even though non-/seldom users had access

to, and utilized, IT-help (as well as access to a computer and the internet) they still did not use the eHealth tool. This indicates that their lower level of interest, or faith, in new information and technology was the bigger obstacle to using the tool.

In **Paper III**, a social component was suggested to help motivate and trigger people with COPD into action, both regarding physical activities and using an eHealth tool. An earlier study by Robinson et al. (139) found that an internet-mediated intervention was significantly beneficial for people with COPD who had a low baseline of self-efficacy when it came to increasing their levels of physical activity. This was somewhat contradictory to what we found, as our data suggested that to benefit from the eHealth tool, users needed to have some level of self-efficacy at the beginning. However, these studies might have other differences, such as the social component layout within the intervention. Robinson et al. (139) mention that their studied intervention includes some social support – which is something that our intervention did not.

In previous studies prompts have been found to enhance the effectiveness of limited contact interventions targeting health behaviors, including physical activity (146-148), and also proved useful for people with COPD (149). Similarly, in our findings, prompts were generally seen as something positive, that they could push people with COPD into action – motivating them.

Lastly, providing efficient and relevant care is dependent on the HCP's knowledge base and the tools they have to help them interpret the situation. Better tools give better possibilities for interpreting the situation and caring for persons with COPD. For example, the findings in **Paper IV** and the development of reference equations and values provide a more efficient way of interpreting the needs of people with COPD. For example, if an HCP can compare the test result of a person with COPD (e.g., the endurance capacity of the quadriceps) with a reference value for the same muscle property, it will give the HCP an important work tool as it will facilitate interpretation of the endurance test performed. Additionally, persons with COPD would get better conditions for their self-management strategies if they got the right advice from the start. This need (for reference values and equations) has repeatedly been requested within the COPD research community (29, 150). Although reference values today exist for muscle strength (2,16,24–27), the development of reference equations (and values) for quadriceps endurance and power is also necessary, considering its high prevalence and link to important clinical outcomes. Furthermore, within the current thesis, the construct

validity of the reference equations for muscle strength has now, for the first time, been documented in people with COPD. Taken together, the findings from this thesis further support and will facilitate the implementation of muscle assessment within the clinical context and in the management of COPD.

Autonomy/agency

Throughout **Paper I** and **Paper II**, autonomy and agency were interpreted as meaningful, for example, in the form of non-/seldom users of the eHealth tool reporting some form of dependency on others. This was also supported by previous research showing that people with low health literacy, in addition to COPD, were seen to be more dependent on others and more concerned about their illness (151, 152). The COPD Web reportedly helped build better communication between persons with COPD and HCP and also helped prepare or inform the person with COPD before the health care meeting, which according to previous research is one reason why eHealth is valuable for creating well-informed and more autonomous individuals (153, 154). The health care visits were perceived (among the HCPs) as more qualitative when using the eHealth tool, due to people with COPD being better equipped for agency – i.e., their ability for self-management was understood to be better. Additionally, HCPs were experiencing the possibility of guiding people with COPD towards a more autonomous behavior when meeting with them and presenting/using individually chosen material from the eHealth tool. This is in line with earlier research where meta-analyses have shown a positive relationship between an autonomy-supportive health care climate, personalization of eHealth intervention content, successful self-management, and behavior change (155, 156).

The eHealth tool was considered as support by both people with COPD and HCPs. It was perceived to provide knowledge support for HCPs, helping them to provide better care for the individuals with COPD that they met and making HCPs want to use the tool more during patient counseling. This was considered helpful also for those professionals that were less knowledgeable in COPD, giving them increased agency with people with COPD. According to the HCPs, the eHealth tool was a way for them to attain a broader and more advanced level of competence regarding COPD, as supported by our own earlier research (157). Knowing more about, e.g., physical activity in COPD made it easier for them to prescribe exercises to people with COPD – ultimately supporting the individual's own agency to manage their condition (158-161). People with COPD, too, were provided with support from the eHealth tool according

to their accounts of getting more knowledgeable and assertive (specifically after 12 months of access to the tool). This is one way of creating more of a sense of autonomy and agency, since knowledge and skill on how to manage the demands of the disease within the daily routines are key to enabling behavior change (52, 132).

Earlier studies suggest that eHealth solutions and control, or patient empowerment, are facilitating factors regarding various disease management/health behaviors, including physical activity (162-164). According to Hong et al. (162), a higher sense of control was connected to an increased level of physical activity, life satisfaction, and fewer perceived constraints. Those with a higher sense of control had also a reduced risk of mortality and lung disease at the four-year follow-up (162). Additionally, an increased sense of control was associated with a reduced level of loneliness and a higher tendency to interact with friends (162). Related to this, social interaction/support was also something that we recognized as a facilitator for increasing physical activity among persons with COPD in **Paper III**.

Disler et al. (163) found that the sense of empowerment could be enhanced among people with COPD. By using tele- and web-based interfaces that gave access to, for example, support regarding medical decisions, self-help, and increased disease-specific knowledge, they felt more confident (163). This is what our employed eHealth tool does too, and so we can assume that the empowerment that people with COPD in **Paper III** express from using the eHealth tool supports the findings from Disler et al. (163). Additionally, our study (**Paper III**) suggested that an eHealth tool could make people with COPD feel more comfortable managing their COPD, their symptoms, and/or their physical activity. It was suggested to help them downsize disease-related fears and understand their body better, as well as the tool, supporting the findings of **Paper I**. Overall, this indicated that the eHealth tool was providing persons with COPD with some tools necessary to manage their condition (52).

Further, the results of **Paper IV** provide an opportunity to customize the treatment for people with COPD so that they themselves get more agency to act in their own best interest. Additionally, HCP are also strengthened and provided with more agency within their working role as they are more able to answer questions and give advice to those who seek their expertise. For example, with developed reference values for different muscle properties, the HCPs will aid in designing and personalizing exercise programs or evaluating the effects of various interventions (29, 38, 165).

Communication

Lastly, concerning communication, that is, the ability for HCPs to communicate (amongst themselves) about and with an individual with COPD. For example, the results of **Paper I** and **Paper II** emphasize how the eHealth tool provided knowledge support, which enhanced communication between colleagues, between HCP and persons with COPD, and vice versa, leading to more qualitative meetings. This (along with more knowledge) could also bridge the power gap that may exist between HCP and patients, when persons with COPD feel more confident in their role as experts of their own bodies. An example of this is expressed by "Kelly", a person with COPD, in **Paper I:**

> *Now, just like then when I was so wilted at Christmastime there, I was the one who stood up for myself and told them that this is the way I am and I now need to come in and perhaps get some help to stop all this. Yes. Not to say… and other times I've let things drag on more. That's just the way it is. But I do understand that it's more important to [seek care] quicker and not let things drag on.*

Newer research supports this in saying that acknowledging the patient's knowledge is essential to level the field, and with technology, the person seeking health care is prone to new and important insights, making them more decisive and knowledgeable (166, 167).

As seen in **Paper II**, power hierarchies between different health care professions could possibly also be reduced by broadening the knowledge base and diminishing the knowledge gap of what the other professions do for the patient group – increasing interprofessional collaboration (as also recommended within pulmonary rehabilitation) (168, 169). HCPs also perceived persons with COPD to be more knowledgeable and ask more questions, and with more substance. However, persons with COPD that reached these gains, were most likely also those that had sufficient communicative and critical health literacy to begin with. People with COPD that were not using the eHealth tool as much, on the other hand, were, similarly, those with poorer communicative and critical health literacy. Thus, based on the findings of this thesis, we would suggest that low (e-)health literacy seems to be important to make health care available through eHealth solutions.

Furthermore, there were, as mentioned before, people with COPD and HCPs that highlighted the problem with internet and/or computer access

or skills. This makes a hindrance in the information and communication of the COPD-specific knowledge targeted by the eHealth tool. This also means that not all are susceptible to the eHealth solution where these media are used. However, we try to accommodate everybody within the informational process (including both HCPs and people with COPD), and we are never going to reach everyone using the same method. Besides access to equipment, there will be varying personalities, perspectives, interests, fears/worries, etcetera, interfering with or promoting certain kinds of communication styles. Additionally, Sönnerfors et al. (170) saw in their study that, among people with COPD in Sweden today, over 90% had access to the internet - while 68% had access to a computer or laptop. Further, 91% had used the internet during the last three months, and 85% used the internet almost daily. So, even though low computer accessibility and skillset is truly an obstacle to using the eHealth tool (133, 171, 172), this is not perhaps the bigger issue to focus on. Notably, even though accessibility for eHealth is good (in Sweden), it is important to acknowledge that people with COPD do not want to replace in-person health care meetings with eHealth. Thus, eHealth should be seen as complementary to standard care and not as a substitute (170).

It is important to note that people with COPD are a heterogeneous group, and there is no way that we can see who will benefit from any treatment until we have asserted who the individual is. This, too, goes for eHealth solutions where we need to establish an honest answer regarding interest, accessibility, state of mind (e.g., fear/curiosity, etc), health literacy, and so on before we suggest the eHealth tool. Also, we need to be open to the fact that it takes time for people to learn and put new skills to use, and perhaps time is sometimes needed to realize that eHealth tools are, or are not, the solution for a certain individual (perhaps at a certain stage in life). Important to remember, however, is that individuals with COPD are never only users or non-users, instead they are reacting to their reality in various ways, and this may mean that one day using an eHealth tool is fine and the next day using the tool is not reasonable.

In **Paper III** we saw that an eHealth tool could help people with COPD to feel more comfortable talking about their own diagnosis with close ones, and the tool could help them teach others about the disease. The feeling was that there was less fear and more understanding when using the eHealth tool to learn more about the condition. Now, this theme of communication is carried on through **Paper IV** in the form of simplifying the interpretation of muscle assessments to provide adequate care. Therefore, also making communicating needs and chosen treatments

more clear and helpful for the individual seeking health care (29, 38, 150, 165).

Methodological considerations

Use of guidelines

For **Paper I – III** it can be considered a strength that the COREQ guidelines (122) were followed when reporting the studies and findings when reflecting on the different ways of doing and reporting a study. Both for securing what information is conveyed to the reader and for the reader to know "how to read" the article in question. One can argue that this provides extra credibility (122). However, there are considerations here as well, in the form of structuring different qualitative methodologies in the same way when reporting results, which might have a restricting effect on some methods (113). Since this work was in the "learning stages" of doing research – and especially qualitative content analysis is rather close to its positivistic ground statements, however, we considered these guidelines helpful and clarifying, rather than restricting. Grounded Theory could possibly be argued to benefit from other guidelines than the qualitative content analysis studies, but since this methodology was used in the learning stages of a research career, it might also be considered more helpful and clarifying than restricting. For **Paper IV**, no reporting guideline was used although we acknowledge that the transparent reporting of a multivariable prediction model for individual prognosis or diagnosis (TRIPOD): The TRIPOD statement, could have been an option (173).

Papers I-III: Strengths and limitations

Strengths of **Papers I-III** include that we have aspired to keep trustworthiness elevated by using investigator triangulation and/or consensus discussions throughout all the phases of the studies in an attempt to make sure that interpretations are not entirely personal for the lonesome analyst, but is somewhat agreed upon by several analysts. This should according to several authors minimize the risk of analyst bias and give the interpretations/observations an enhanced trustworthiness (specifically *dependability* according to Graneheim et al. and *credibility* according to Thurmond and Sikolia et al.) (126, 174, 175). Besides this, audio recordings provided extra interpretation assistance as they contained intonations and other auditory clues as to the underlying meaning of a statement. When reporting our findings, we used

representative citations as a way of being transparent about our interpretations, thus increasing credibility and authenticity (174).

All studies used one-on-one interviews, some conducted face-to-face and some conducted via telephone (according to the practicality of the situation at hand). Earlier research supports that neither of these in-person or telephone-based settings is better than the other, but simply different (176, 177). To make the interview situation as welcoming, open, and safe as possible for the interviewee, we aspired to let the interviewee decide on location and time as far as it was possible. This was also made in an effort to level out the power differences between the interviewer and interviewee. We additionally made sure, as far as we could, that the interviewer and interviewee were the only ones participating in the conversation so that they weren't feeling overheard or cut off by others, as well as not having to follow other social norms/rules that weren't already in place between the interviewer and interviewee themselves.

In **Papers I – II** the second interview occasion rendered very few interviewees, and within all interviews the content richness was varying, something that can affect the transferability of the findings according to Graneheim et al. (174). However, the richness of the data was deemed adequate for the analyses made, we also kept aware of appropriately abstracting according to the data at hand (123). In the first study, the study participants were mainly women, living alone, and with an overall low disease severity, which might affect the answers we got and which should be noted, e.g., for those wanting to transfer some measure of the findings onto their own patient group. A strength of the same study was the ability to make some comparisons between "users" and "non-/seldom users" using objective measures, as well as these cut-offs being made 1) by a researcher not involved in the primary analysis, 2) after data was already coded, and 3) before codes were tracked back to individual informants. A limitation regarding this, however, was that the objective measures were only available for the initial 3 months and not at the 12-month follow-up. This makes it impossible for us to do the same objectively based comparison at the later interview occasion. Notably, the division into "users" and "non-/seldom users" was done as part of the analysis (and was not predetermined) which could be seen as a limitation. However, the division was performed by one of the co-authors not involved in the coding.

Regarding strengths specifically of **Paper II,** our participants were of multidisciplinary health care professions and the use of the COPD Web as part of their ordinary work practice was not aided by any extra resources to the primary health care unit (178). Making it as close to a "real-world" scenario as possible. Additionally, interviews at the 12-month follow-up proved very valuable in providing insight into HCPs' need for time when implementing an eHealth tool (140, 141). In **Papers I – III** the main analysts did not participate in the development of the eHealth tool, nor in the interviewing, which can be seen as a helpful outsider's perspective when evaluating how the tool has worked. However, it might also give less insight into how the eHealth tool works and is built, as well as perhaps limiting the possibility to ask more/other questions to the participants. In **Paper III** the main analyst is also the interviewer, which brings another aspect to the table – questions might be very different from what the developers themselves might ask, and this can be seen as a strength as novel information has the opportunity to arise from the unexpected. In the conversation with the interviewee, the interviewer might also be able to help facilitate honest and elaborate statements from the participant.

In a GT study, following Charmaz, the main investigator should not have too many preconceptions about the subject in question (125). All but one author had previous in-depth knowledge about COPD, only one had not worked with qualitative research methods before and two authors had worked with GT before. This brought a relatively experienced group of authors for this subject, making analytic discussions interesting and relatively diverse. Within the CGT method, the subjectivity of the investigator is considered a strength, since data is co-constructed by investigators and study participants (125). In our study, this has most probably meant that our (the researchers) collective previous knowledge of, e.g., COPD, physiotherapy, and sociology shaped what we thought important to highlight (and analyze) from what our participants expressed. If someone else were to analyze the same material, they might highlight something different and show us something else.

Paper IV: Strengths and limitations

Paper IV had a strength in that it was a multicenter study, which enabled a varied sample for our healthy population as well as our population with COPD. In turn, that gave us the possibility of stronger external validity and generalizability regarding our findings. Still, there will most likely occur some human errors, so making sure to use validated protocols and standardizing our procedures across the three centers was a way to minimize the weight of these errors on the final results. Regarding the

usage of LLN and <80% of predicted value, we decided to use both as they are commonly used cut-offs in previous literature (12, 179-181). The LLN is strongly recommended and regularly used when determining lung function impairment and is less arbitrary cut-off than the <80% of predicted value. However, as the latter has been used in previous literature on muscle assessments we decide to also use this cut-off to facilitate interpretation and comparisons.

A limitation of the study might be that the reference equations developed in this study were applied to a group of people with COPD that was largely retrospective. However, all people with COPD were recruited from the study centers involved in the study, and all study procedures were standardized (as stated above). Another limitation was the disease severity of the group with COPD, which although all disease stages were included (mild to very severe airflow obstruction), included patients with COPD that had a relatively well-preserved functional exercise capacity. This means that generalization to people with COPD with a more impaired functional exercise capacity should be made with caution.

Lastly, when assessing the isometric and dynamic muscle properties of the quadriceps a computerized dynamometer was utilized, a piece of expensive and bulky equipment not usually present in the clinical setting. In the clinical setting, one might instead need to use cheaper equipment, such as using weight machines for isotonic testing and fixed handheld dynamometry for isometric testing – the latter has shown very good agreement with the output from a computerized dynamometer (37).

Clinical implications and conclusion

The overall aim of this thesis was to explore the conditions for, and perspectives on, evidence-based care and eHealth in COPD management. Briefly put, the four papers were meant as a means to improve COPD care as they try to answer questions regarding what people with COPD need to manage their symptoms, and how the HCP can be helped in their work to improve the situation for the COPD population. Thus, potential clinical implications of the research findings have been central throughout the thesis and the individual papers.

Concerning our **aim** to explore and describe the experiences of people with COPD regarding using an eHealth tool over time and factors that might affect usage, the findings from **Paper I** suggest that:

- using an eHealth tool might be in some effect depending on one's view of information. Curiosity and fear of new information were seen to influence whether one used an eHealth tool or not.
- a higher level of motivation, IT skills, and/or health literacy also seem to act as facilitators for the usage of an eHealth tool. Non-/seldom users seem to struggle with low motivation, a need for technical support, and a problematic health literacy score. Users, on the other hand, reported themselves as comfortable with IT tools and a sufficient health literacy score.
- time is a facilitator in terms of reaping the benefits from using an eHealth tool, and it was suggested that when we try out an eHealth tool with regard to behavioral changes, we should give it some time before evaluating its potential benefits.

From a clinical perspective: all in all, many insights can come from knowing more about the users' and non-/seldom users' experiences and presuppositions regarding using (or not) an eHealth tool with the purpose of bettering access to self-management strategies among people with COPD. Firstly, we can get a glimpse of *whom* to offer/prescribe this type of tool to. We might, according to our findings, be helping more people if some get access to the eHealth tool and some continue with the traditional ways of information (physical visits to the HCP). In this case, the findings suggest that the person who might benefit more from an eHealth tool is somewhat IT-savvy and comfortable, have a less problematic health literacy scoring, and are interested. They might have to feel rather unafraid too, seeing as new information about a chronic disease can be

frightening and off-putting. Secondly, we should offer people with COPD time to get to know and use the tool, incorporate it into their everyday lives, and have a chance to experience any possible changes in health.

Concerning our **aim** to explore the experiences of using an eHealth tool among HCPs that worked with people with COPD in daily clinical practice, the findings from **Paper II** suggest that:

- an eHealth tool can provide support for HCP in the form of acting as a knowledge platform for all HCP working with people with COPD.
- an eHealth tool also seems to be helpful with improving the quality of care by, e.g., encouraging interprofessional collaboration, enhancing patient contact, and helping HCPs with adapting and facilitating working procedures and person-centered care.
- HCPs perceived people with COPD to be better equipped to tackle their disease and adhere better to treatment when they had been using the eHealth tool. This, in turn, made the HCPs feel that people with COPD were better able to perform self-management.
- structural and external barriers regarding time, support, and education need to be addressed to successfully implement an eHealth tool within a health care setting's daily praxis.

From a clinical perspective: the findings in **Paper II** suggest that the (quality of) health care for people with COPD can be supported and enhanced when using an eHealth tool that provides the whole workforce with a uniform information basis. This might also improve the work environment for the HCPs that work with COPD, as well as the patient safety, by the improved communication between HCPs as well as between HCP and persons with COPD. Further, we suggest that the implementation process might need to be reviewed regarding eHealth tools within a health care setting.

Concerning our **aim** to identify enablers and barriers for the use of web-based support with the COPD Web to change behavior, the findings from **Paper III** suggest that:

- eHealth tools should be considered for those with some level of baseline self-efficacy, among other things, and thereby seem to contradict an earlier study by Robinson et al. (139) where also people with COPD with a lower baseline of self-efficacy were seen to enhance their physical activity level. This could, however, be

related to the layout of the intervention and may benefit from being examined more.

- an eHealth solution and control, or patient empowerment, are facilitators regarding different disease management – including physical activity. We also found that the social factor was interpreted as a facilitator for increasing one's physical activity, it was perceived as motivating, engaging, and triggering.
- people with COPD could increase their sense of empowerment from the usage of tele- and web-based interfaces which gave them access to, for example, self-help, support on medical decisions, and increased knowledge regarding their condition. This could make people with COPD more confident and it was corroborated in our study where they felt more confident with this kind of help.
- eHealth might be a helpful tool for increasing levels of physical activity among people with COPD
- an eHealth tool seemed able to help people with COPD more comfortable managing their disease, the symptoms, and/or physical activity.

From a clinical perspective: our data suggested (most importantly) that a certain sense of control is deemed necessary for improving one's physical activity and for using an eHealth tool in order to assist in increasing the physical activity level. The eHealth tool itself seemed to help boost, or hinder, the feeling of control by either supporting the user – or demanding too much from the same. Important to note is that no user was only "strengthened" or "weakened" by the eHealth tool. What the study most reinforces is the importance of empowering people with COPD so that their level of agency is increased – and with that, their ability to boost levels of physical activity.

Concerning our **aims** to 1) develop reference equations to obtain predicted values for quadriceps strength, endurance, and power in healthy individuals, to 2) test the reference equations in people with COPD to establish the prevalence rate of reduced muscle strength, endurance, and power in this population, and to 3) explore the construct validity of the proposed equations by documenting evaluating the relationships between quadriceps properties and functional capacity in people with COPD, the findings from **Paper IV** suggests that:

- new reference equations and predictive values of different quadriceps properties could be developed, which will facilitate the clinical interpretation of future muscle assessments.
- age, sex, height, and BMI seem to explain about 50 – 70% of the total variance in isometric strength, isotonic and isokinetic endurance, and power of the quadriceps in healthy individuals.
- applying the developed reference equations in people with COPD, our findings show that isometric strength, isotonic and isokinetic endurance, as well as isokinetic power were lowered in 14, 43 and 26, as well as 36% of the individuals when the normality threshold was set at the 5th percentile.
- among people with COPD, the quadriceps properties were mainly moderately correlated with 6MWD and 1STS results supporting the construct validity of the reference equations as the strength and the direction of the correlations seen were similar to what previously has been observed using direct measurements of various quadriceps properties (36).

From a clinical perspective: we know today that assessment of limb muscle functions is highly valued as it can help HCPs to systematically identify the current issues and relevant personalized interventions for persons with COPD (15). Knowing if or whether a person with COPD has a muscle limitation pertaining to a certain muscle property (or several) would call upon somewhat different methods of treatment, which now is possible with the development of new reference equations and predictive values. For example, a low function of muscle strength would benefit from a regime of low repetition – high resistance training (182). Meanwhile, low muscle endurance would benefit from a regime of high repetition – low resistance training (182). Thus, the findings from **Paper IV** will support HCP to better prescribe the correct treatment for each individual seeking health care and will further improve disease management.

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I could go on forever because there are so many people involved in my success with this work, but be sure to know that if you have been a part of my life – you are deserving of a grateful thought!
I trust you know who you are. ♥

Appendix

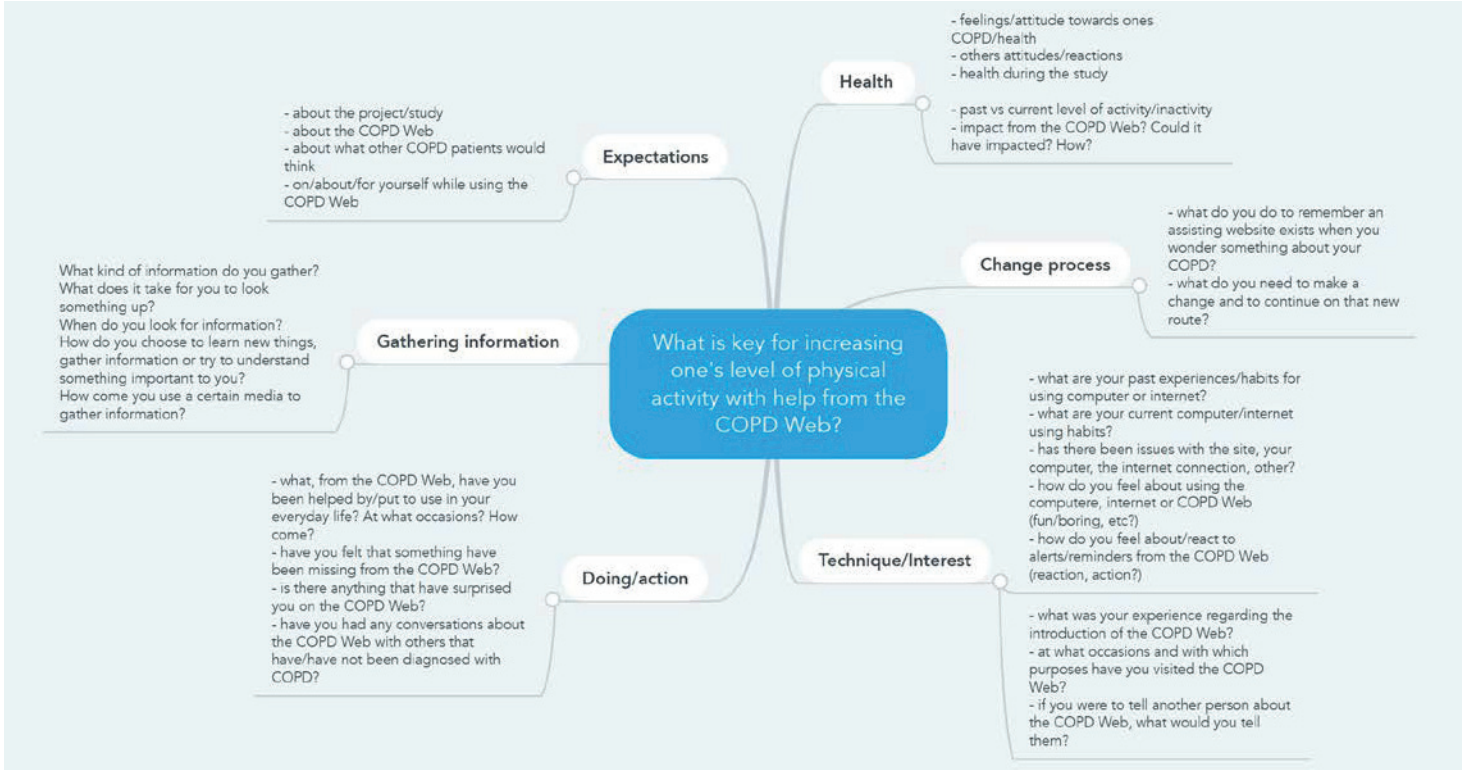
Appendix 1: Interview guide for Paper II.

Instructions for the interview guide

The interview is part of the development/evaluation of the COPD Web. The purpose of the interview is to understand and gain knowledge about the experiences of healthcare professionals who have used the COPD Web. The guide is based on a narrative approach, i.e., the questions should be formulated so that they invite the research subject to tell freely about their experiences – if necessary, use exploratory follow-up questions such as "can you tell us more?" or "what did you think then?"

Interview parts	Examples of questions
User habits (with starting question)	Tell me about if/how you have used the COPD Web (during this time) For what purpose/purposes have you visited the COPD Web?
User experience	Have you identified yourself as a healthcare professional with the contents on the COPD Web? How do you perceive the COPD Web to navigate/navigate on the Internet? Have you missed anything in particular on the COPD Web? How can the COPD Web be improved for you as a healthcare professional? How have you perceived the [films/information/how information is presented/the amount of information]?
Potential contribution to clinical work	Have using the COPD Web had any impact on your interaction with the patient during consultation – both positive and negative? Has using the COPD Web impacted your security in the professional role? Has using the COPD Web impacted your collaboration with other professions?
Experiences of the eHealth tool when working with patients with COPD	How did patients experience using the COPD Web? How did patients with COPD perceive the information on the COPD Web? Was there any potential benefit of using the COPD Web among patients? Could the content of the COPD Web be individualized to people with COPD with different disease severity/age/ gender/ degree of comorbidities etc.?
Future use	Is there anything you feel could be enhanced/developed on the COPD Web? What are your thoughts about continuing to use the COPD Web in the future?
Usual finishing question	Is there anything else you have thought about/would like to say about the COPD Web that I have not asked about?

Appendix 2: Interview guide for Paper III, divided into areas with suggestions of questions/follow-up questions.



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2. *Inger Wadell*. Influences from peripheral sense organs on primary and secondary spindle afferents via gamma-motoneurones - A feedback mechanism for motor control and regulation of muscle stiffness. Umeå University Medical Dissertations, New Series no 307, 1991 (Department of Physiology)
3. *Jessica Elert*. The pattern of activation and relaxation during fatiguing isocinetic contractions in subjects with and without muscle pain. Arbete och hälsa 1991:47. Diss. 1992 (sammanfattning). (Departments of Clinical Physiology, National Institute of Occupational Health and Physical Medicine and Rehabilitation)
4. *Gunnevi Sundelin*. Electromyography of shoulder muscles - The effects of pauses, drafts and repetitive work cycles. Arbete och Hälsa, 1992:16. Diss. (sammanfattning). (Departments of Anatomy, National Institute of Occupational Health, Division of Work and Environmental Physiology, Divisions of Occupational Medicine and Applied Work Physiology and Occupational Medicine)
5. *Birgit Rösblad*. Visual and proprioceptive control of arm movement - Studies of development and dysfunction. Diss. (sammanfattning) 1994 (Department of Paediatrics)
6. Charlotte Häger-Ross. To grip and not to slip - Sensorimotor mechanisms during reactive control of grasp stability. Umeå University Medical Dissertations, New Series no 429, 1995 (Department of Physiology)
7. *Lars Nyberg*. Falls in the frail elderly – Incidence, characteristics and prediction with special reference to patients with stroke and hip fractures. Umeå Medical Dissertations, New Series no 483, 1996 (Department of Geriatric Medicine)
8. *Margareta Barnekow-Bergkvist*. Physical capacity, physical activity and health -A population based fitness study of adolescents with an 18-year follow-up. Umeå University Medical Dissertations, New Series no 494, 1997 (Departments of Physiology and Technology, National Institute for Working Life and Epidemiology and Public Health)
9. *Britta Lindström*. Knee muscle function in healthy persons and patients with upper motor neurone syndrome. Umeå University

Medical Dissertations, New Series no 505, 1997 (Departments of Physical Medicine and Rehabilitation and Clinical Neuroscience)

10. *Monica Mattsson*. Body Awareness - applications in physiotherapy. Umeå University Medical Dissertations, New Series no 543, 1998 (Departments of Psychiatry and Family Medicine)
11. *Hildur Kalman*. The structure of knowing. Existential trust as an epistemological category. Umeå studies in the humanities. 145, 1999 (Department of Philosophy and Linguistics
12. *Hamayun Zafar*. Integrated jaw and neck function in man: studies of mandibular and head-neck movements during jaw opening-closing tasks. Umeå University Medical Dissertations, New series no 74, 2000 (Departments of Odontology, Clinical Oral Physiology and Centre for Musculoskeletal Research, National Institute for Working Life, Umeå)
13. *Lillemor Lundin-Olsson*. Prediction and prevention of falls among elderly people in residential care. Umeå University Medical Dissertations, New Series no 671, 2000 (Department of Community Medicine and Rehabilitation, Physiotherapy and Geriatric Medicine)
14. *Christina Ahlgren*. Aspects of rehabilitation – with focus on women with trapezius myalgia. Umeå University Medical Dissertations, New Series no 715, 2001 (Department of Public Health and Clinical Medicine, Occupational Medicine)
15. *Ann Öhman*. Profession on the move - changing conditions and gendered development in physiotherapy. Umeå University Medical Dissertations, New series No 730, 2001 (Departments of Community Medicine and Rehabilitation, Physiotherapy and Public Health and Clinical Medicine, Epidemiology)
16. *Kerstin Söderman*. The female soccer player – Injury pattern, risk factors and intervention. Umeå University Medical Dissertations, New series no 735, 2001 (Departments of Surgical and Perioperative Sciences, Sports Medicine, and Community Medicine and Rehabilitation, Physiotherapy)
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19. *Eva-Britt Malmgren-Olsson*. Health problems and treatment effects in patients with non-specific musculoskeletal disorders. A comparison

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20. *Jane Jensen.* Fall and injury prevention in older people living in residential care facilities. Umeå University Medical Dissertations, New series no 812, 2003 (Department of Community Medicine and Rehabilitation, Physiotherapy and Geriatric Medicine)
21. *Anncristine Fjellman-Wiklund.* Musicianship and teaching. Aspects of musculoskeletal disorders, physical and psychosocial work factors in musicians with focus on music teachers. Umeå University Medical Dissertations, New series no 825, 2003 (Department of Community Medicine and Rehabilitation, Physiotherapy)
22. *Börje Rehn.* Musculoskeletal disorders and whole-body vibration exposure among professional drivers of all-terrain vehicles. Umeå University Medical Dissertations, New series no 852, 2004 (Department of Public Health and Clinical Medicine, Occupational Medicine)
23. *Martin Björklund.* Effects of repetitive work on proprioception and of stretching on sensory mechanisms. Implications for work-related neuromuscular disorders. Umeå University Medical Dissertations, New series no 877, 2004 (Department of Surgical and Perioperative Sciences, Sports Medicine Unit, Umeå University, The Center for Musculoskeletal Reseach, University of Gävle, Umeå, and Alfta Forskningsstiftelse, Alfta)
24. *Karin Wadell.* Physical training in patients with chronic obstructive pulmonary disease – COPD. Umeå University Medical Dissertations, New series no 917, 2004 (Departments of Community Medicine and Rehabilitation, Physiotherapy; Public Health and Clinical Medicine, Respiratory Medicine and Allergy, Surgical and Perioperative Sciences, Sports Medicine)
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26. *Ulrika Aasa.* Ambulance work. Relationships between occupational demands, individual characteristics and health related outcomes. Umeå University Medical Dissertations, New series no 943, 2005 (Department of Surgical and Perioperative Sciences, Sports Medicine and Surgery, University of Umeå and Centre for Musculoskeletal Research, University of Gävle)

27. *Ann-Katrin Stensdotter*. Motor Control of the knee. Kinematic and EMG studies of healthy individuals and people with patellofemoral pain. Umeå University Medical Dissertations, New series no 987, 2005 (Department of Community Medicine and Rehabilitation, Physiotherapy)
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33. *Gerd Flodgren*. Effect of low–load repetitive work and mental load on sensitising substances and metabolism in the trapezius muscle. Umeå University Medical Dissertations, New series no 1130, 2007 (Department of Surgical and Perioperative Sciences, Sports Medicine Unit, Centre of Musculoskeletal Research, University of Gävle, Umeå, and the Department of Community Medicine and Rehabilitation, Rehabilitation Medicine)
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35. *Jonas Sandlund*. Position-matching and goal-directed reaching acuity of the upper limb in chronic neck pain: Associations to self-rated characteristics. Umeå University Medical Dissertations, New series no

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36. *Gunilla Larsson.* Motor function over time in Rett syndrome-loss, difficulties and possibilities. Umeå University Licentiate Thesis, 2008 (Department of Community Medicine and Rehabilitation, Physiotherapy)
37. *Charlotte Åström.* Effects of vibration on muscles in the neck and upper limbs. With focus on occupational terrain vehicle drivers. Umeå University Medical Dissertations, New series no 1135, 2008 (Department of Community Medicine and Rehabilitation, Physiotherapy)
38. *Ellinor Nordin.* Assessment of balance control in relation to fall risk among older people. Umeå University Medical Dissertations, New series no 1198, 2008 (Department of Community Medicine and Rehabilitation, Physiotherapy)
39. *Bertil Jonsson.* Interaction between humans and car seat. Studies of occupant seat adjustment, posture, position and real world neck injuries in rear-end impacts. Umeå University Medical Dissertations, New Series no 1163, 2008 (Department of Surgical and Perioperative Sciences, Sports Medicine Unit)
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41. *Therese Stenlund.* Rehabilitation for patients with burn out. Umeå University Medical Dissertations, New series no 1237, 2009 (Department of Public Health and Clinical Medicine, Occupational and Environmental Medicine)
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47. *Per Jonsson*. Eccentric training in the treatment of tendinopathy. Umeå University Medical Dissertations, New series no 1279, 2009 (Department of Surgical and Perioperative Sciences, Sports Medicine Unit)
48. *Taru Tervo*. Physical activity, bone gain and sustainment of peak bone mass. Umeå University Medical Dissertations, New series no 1282, 2009 (Department of Surgical and Perioperative Sciences, Sports Medicine, Department of Community Medicine and Rehabilitation, Geriatric Medicine, Department of Community Medicine and Rehabilitation, Rehabilitation Medicine)
49. *Kajsa Gilenstam*. Gender and physiology in ice hockey: a multidimensional study. Umeå University Medical Dissertations, New series no 1309, 2010 (Department of Surgical and Perioperative Sciences, Sports Medicine Unit)
50. *Margareta Eriksson*. A 3-year lifestyle intervention in primary health care. Effects on physical activity, cardiovascular risk factors, quality of life and costeffectiveness. Umeå University Medical Dissertations, New series no 1333, 2010 (Department of Community Medicine and Rehabilitation, Physiotherapy and Department of Public Health and Clinical Medicine, Epidemiology and Public Health Sciences)
51. *Eva Holmgren*. Getting up when falling down. Reducing fall risk factors after stroke through an exercise program. Umeå University Medical Dissertations, New series no 1357, 2010 (Department of Community Medicine and Rehabilitation, Physiotherapy and Department of Public Health and Clinical Medicine, Medicine)
52. *Tania Janaudis Ferreira*. Strategies for exercise assessment and training in patients with chronic obstructive pulmonary disease. Umeå University Medical Dissertations, New series no 1360, 2010 (Department of Community Medicine and Rehabilitation, Physiotherapy)

53. *Sólveig Ása Árnadóttir*. Physical activity, participation and self-rated health among older community-dwelling Icelanders. A population-based study. Umeå University Medical Dissertations, New series no 1361, 2010 (Department of Community Medicine and Rehabilitation, Physiotherapy)
54. *Maria Wiklund*. Close to the edge. Discursive, embodied and gendered stress in modern youth. Umeå University Medical Dissertations, New series no 1377, 2010 (Department of Public Health and Clinical Medicine, Epidemiology and Global Health and Department of Community Medicine and Rehabilitation, Physiotherapy)
55. *Catharina Bäcklund*. Promoting physical activity among overweight and obese children: Effects of a family-based lifestyle intervention on physical activity and metabolic markers. Umeå University 2010 (Department of Food and Nutrition)
56. *Helene Johansson*. En mer hälsofrämjande hälso- och sjukvård: hinder och möjligheter utifrån professionernas perspektiv. Umeå University Medical Dissertations, New series no 1388, 2010 (Department of Public Health and Clinical Medicine, Epidemiology and Global Health)
57. *Håkan Littbrand*. Physical exercise for older people: focusing on people living in residential care facilities and people with dementia. Umeå University Medical Dissertations, New series no 1396, 2011 (Department of Community Medicine and Rehabilitation, Geriatric Medicine and Physiotherapy)
58. *Marlene Sandlund*. Motion interactive games for children with motor disorders. Umeå University Medical Dissertations, New series no 1419, 2011 (Department of Community Medicine and Rehabilitation, Physiotherapy)
59. *Ann Sörlin*. Health and the Elusive Gender Equality. Can the impact of gender equality on health be measured? Umeå University Medical Dissertations, New series no 1420, 2011 (Department of Public Health and Clinical Medicine, Epidemiology and Global Health)
60. *Björn Sundström*. On diet in ankylosing spondylitis. Umeå University Medical Dissertations, New series no 1440, 2011 (Department of Public Health and Clinical Medicine, Rheumatology)
61. *Gunilla Stenberg*. Genusperspektiv på rehabilitering för patienter med rygg- och nackbesvär i primärvård. Umeå University Medical Dissertations, New series no 1482, 2012 (Department of Community Medicine and Rehabilitation, Physiotherapy and Umeå centre for Gender Studies)
62. *Mia Conradsson*. Physical exercise and mental health among older people - measurement methods and exercise effects with focus on people living in residential care facilities. Umeå University Medical

Dissertations, New series 1537, 2012 (Department of Community Medicine and Rehabilitation, Geriatric Medicine)

63. *Mattias Hedlund.* Biomechanical and Neural Aspects of Eccentric and Concentric Muscle Performance in Stroke Subjects. Implications for resistance training. Umeå University Medical Dissertations, New series no 1510, 2012 (Department of Community Medicine and Rehabilitation, Physiotherapy)
64. *Joakim Bagge.* TNF-alfa och neurotrophins in achilles tendinosis. Umeå University Medical Dissertations, New series no 1538, 2013 (Department of Integrative Medical Biology, Anatomy and Department of Surgical and Perioperative Sciences, Sports Medicine)
65. *Gunilla Larsson.* Motor development, mobility and orthostatic reactions in Rett syndrome. Loss of function, difficulties and possibilities. Umeå University Medical Dissertations, New series no 1566, 2013 (Department of Community Medicine and Rehabilitation, Physiotherapy)
66. *Ludvig J Backman.* Neuropeptide and catecholamine effects on tenocytes in tendinosis development. Studies on two model systems with focus on proliferation and apoptosis. Umeå University Medical Dissertations, New series no 1572, 2013 (Department of Integrative Medical Biology, Anatomy and Department of Surgical and Perioperative Sciences, Sports Medicine)
67. *Sven Blomqvist.* Postural balance, physical activity and capacity among young people with intellectual disability. Umeå University Medical Dissertations, New series no 1579, 2013 (Department of Community Medicine and Rehabilitation, Physiotherapy)
68. *Eva Tengman.* Long-term consequences of anterior cruciate ligament injury. Knee function, physical activity level, physical capacity and movement pattern. Umeå University Medical Dissertations, New series no 1631, 2014 (Department of Community Medicine and Rehabilitation, Physiotherapy)
69. *Andre Nyberg.* Single limb exercises in patients with chronic obstructive pulmonary disease. Feasibility, methodology, effects and evidence. Umeå University Medical Dissertations, New series no 1645, 2014 (Department of Community Medicine and Rehabilitation, Physiotherapy)
70. *Maria Strömbäck.* Skapa rum. Ung femininitet, kroppslighet och psykisk ohälsa – genusmedveten och hälsofrämjande intervention. Umeå University Medical Dissertations, New series no 1655, 2014 (Department of Community Medicine and Rehabilitation, Physiotherapy, Clinical Science, Psychiatry and Umeå Centre for Gender Studies, National Research School for Gender Studies)
71. *Joakim Bjerke.* Gait and postural control after total knee arthroplasty. Umeå University Medical Dissertations, New series no 1664, 2014

(Department of Community Medicine and Rehabilitation, Physiotherapy)

72. *Elisabet Sonntag-Öström.* Forest for rest. Recovery from exhaustion disorder. Umeå University Medical Dissertations, New series no 1667, 2014 (Department of Public Health and Clinical Medicine, Occupational and Environmental Medicine)
73. *Maria Sehlin.* Resistance breathing with PEP and CPAP. Effects on respiratory parameters. Umeå University Medical Dissertations, New series no 1674, 2014 (Department of Surgical and Perioperative Sciences, Anaesthesiology and Intensive Care Medicine, Department of Community Medicine and Rehabilitation, Physiotherapy, Department of Radiation Sciences, Biomedical Engineering)
74. *Petra Pohl.* Falls in older community-dwelling women and men: risk factors and safety strategies. Fall risk awareness, fear of falling, and preferred exercise properties from a gender perspective. Umeå University Medical Dissertations, New series No 1692, 2015 (Department of Community Medicine and Rehabilitation, Physiotherapy)
75. *Gudrun Johansson.* Clinical and kinematic assessments of upper limb function in persons with post-stroke symptoms. Umeå University Medical Dissertations, New series No 1722, 2015 (Department of Community Medicine and Rehabilitation, Physiotherapy)
76. *Camilla Sandberg.* Physical performance, physical activity, body composition and exercise training in adults with congenital heart disease. Umeå University Medical Dissertations, New series No 1758, 2016 (Department of Public Health and Clinical Medicine, Medicine, Department of Community Medicine and Rehabilitation, Physiotherapy)
77. *Tobias Stenlund.* Seated postural reactions to mechanical shocks. Laboratory studies with relevance for risk assessment and prevention of musculoskeletal disorders among drivers. Umeå University Medical Dissertations, New series No 1780, 2016 (Department of Community Medicine and Rehabilitation, Physiotherapy)
78. *Anna Bråndahl.* Rehabilitation after stroke with focus on early supported discharge and post-stroke fatigue. Umeå University Medical Dissertations, New series No 1817, 2016 (Departments of Public Health and Clinical Medicine, Medicine, and Community Medicine and Rehabilitation, Physiotherapy)
79. *Lars Berglund.* Deadlift training for patients with mechanical low back pain: a comparison of the effects of a high-load lifting exercise and individualized low-load motor control exercises. Umeå University Medical Dissertations, New series No 1806, 2016 (Department of Community Medicine and Rehabilitation, Physiotherapy, Department of Surgical and Perioperative Sciences, Orthopaedics)

80. *Peter Flank*. Spinal cord injuries in Sweden: studies on clinical follow-ups. Umeå University Medical Dissertations, New series No 1824, 2016 (Department of Community Medicine and Rehabilitation, Rehabilitation Medicine)
81. *Annika Toots*. Gait speed and physical exercise in people with dementia. Umeå University Medical Dissertations, New series No 1866, 2016 (Department of Community Medicine and Rehabilitation, Geriatric medicine and Physiotherapy)
82. *Cecilia Wahlström Edling*. Musculoskeletal disorders in music teachers and their view on young music student' health – Visions and reality in contradiction. Umeå University Licentiate Thesis 2017. (Department of Community Medicine and Rehabilitation, Physiotherapy and Umeå Centre for Gender Studies)
83. *Åsa Svedmark*. Neck pain in women – Effect of tailored and impact of work environment. Umeå University Medical Dissertations, New series No 1916, 2017 (Department of Community Medicine and Rehabilitation, Physiotherapy)
84. *Anna Stecksén*. Stroke thrombolysis on equal terms? Implementation and ADL outcome. Umeå University Medical Dissertations, New series No 1917, 2017 (Department of Public Health and Clinical Medicine, Medicine, and Department of Community Medicine and Rehabilitation, Physiotherapy)
85. *Kristina Hörnberg*. Aspects of physical activity in rheumatoid arthritis. Associations with inflammation and cardiovascular risk factors. Umeå University Dissertations, New series no 1949, 2018 (Department of Public Health and Clinical Medicine, Rheumatology)
86. *Elisabeth Pietilä-Holmner*. Multimodal Rehabilitation of Patients with Chronic Musculoskeletal Pain, focusing on Primary Care. Umeå University Medical Dissertations, New series No 1970, 2018 (Department of Community Medicine and Rehabilitation, Rehabilitation medicine)
87. *Sara Lundell*. COPD in primary care. Exploring conditions for implementation of evidence-based interventions and eHealth Care. Umeå University Medical Dissertations, New series No 1982, 2018 (Department of Community Medicine and Rehabilitation, Physiotherapy) and Department of Radiation Sciences, Radiation physics and Biomedical Engineering)
88. *Frida Bergman*. Active workstations – a NEAT way to prevent and treat overweight and obesity. Umeå University Medical Dissertations, New series No 1981, 2018 (Departments of Public Health and Clinical Medicine, Medicine and Community Medicine and Rehabilitation, Physiotherapy)
89. *Haleluya Moshi*. Traumatic spinal cord injuries in rural Tanzania. Occurrence, clinical outcomes and life situation of persons living in

the Kilimanjaro region. Umeå University Medical Dissertations, New series No 1988, 2018 (Department of Community Medicine and Rehabilitation, Physiotherapy.)

90. *Claes Göran Sundell.* Low back pain in Adolescent Athletes. Umeå University Medical Dissertations, New series No 2014, 2019 (Department of Community Medicine and Rehabilitation)
91. *Viktoria Wahlström.* Intervention for increased physical activity among office workers. Umeå University Medical Dissertations, New series No 2053, 2019 (Department of Public Health and Clinical Medicine, Section for Sustainable Health)
92. *Anna Sondell.* Exercise and team rehabilitation in older people with dementia: applicability, motivation and experiences. Umeå University Medical Dissertations, New series No 2064, 2020 (Department of Community Medicine and Rehabilitation, Physiotherapy)
93. *Veronica Lundberg*. Children with Juvenile Idiopathic Arthritis, Health-related quality of life and participation in healthcare encounters. Umeå University Medical Dissertations, New series No 2088, 2020 (Department of Community Medicine and Rehabilitation, Physiotherapy)
94. *Åsa Karlsson.* Team-based home rehabilitation after hip fracture in older adults – effects, experiences and impact of dementia. Umeå University Medical Dissertations, New series No 2112, 2021 (Department of Community Medicine and Rehabilitation, Geriatric medicine and Physiotherapy)
95. *Linda Månsson*. Digital fall prevention for older adults – Feasibility of a self-managed exercise application and development of a smartphone self-test for balance and leg strength. Umeå University Medical Dissertations, New series No 2113, 2021 (Department of Community Medicine and Rehabilitation, Section of Physiotherapy, and Department of Radiation Sciences, Radiation Physics and Biomedical Engineering)
96. *Beatrice Pettersson.* Fall prevention exercise for older adults – Self-management with support of digital technology. Umeå University Medical Dissertations, New series No 2122, 2021 (Department of Community Medicine and Rehabilitation, Section of Physiotherapy)
97. *Erik Frykholm*. The relevance and assessment of limb muscle function in individuals with chronic obstructive pulmonary disease, New series No 2145, 2021 (Department of Community Medicine and Rehabilitation, Section of Physiotherapy)
98. *Heidi Nedergård.* Taking the next step. Whole-body biomechanical gait analysis, and user-perspectives on robotic-assisted gait training post-stroke. Umeå University Medical Dissertations, New series No 2151, 2021 (Department of Community Medicine and Rehabilitation, Section of Physiotherapy)

99. *Jerry Öhlin*. Gait speed, physical activity, cognitive function and dementia: associations in cross-sectional and longitudinal srudies and validity of a physical activity questionnaire in very old people. Umeå University Medical Dissertations. New series No 2146, 2021 (Department of Community Medicine and Rehabilitation, Department of Public Health and Clinical Medicine, Department of nursing, Geriatric medicine and Physiotherapy)
100. *Matthias Tegern*. Musculoskeletal disorders in Swedish military aircrew. Screening and clinical examination of the cervico-thoracic region. Umeå University Medical Dissertations, New Series No 2167, 2021 (Department of Community Medicine and Rehabilitation, Section of Physiotherapy)