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Implications of research practices – the case of studying breast cancer survivors

Doctoral thesis

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Norwegian University of Science and Technology
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Avhandlingens tittel på norsk:

Sosial ulikhet i fysisk aktivitet

Implikasjoner av forskningspraksis - forskning på brystkreftoverlevere som case

Kort og beskrivende populærvitenskapelig tittel (på norsk):

Sosial ulikhet i fysisk aktivitet – har vi feil fokus?

Parallelt med vedvarende sosiale helseulikheter, viser stadig mer forskning at det er en sammenheng mellom fysisk aktivitet og god helse. Det har vært en utbredt oppfatning blant forskere at lavere sosioøkonomiske grupper er mindre fysisk aktive enn de med høyere sosioøkonomisk status. Når helsefremmende tiltak for fysisk aktivitet rettet mot grupper med lavere sosioøkonomisk status ikke nødvendigvis fører til mer slik aktivitet, er det grunn til å spørre om forståelsen av sammenhengen mellom fysisk aktivitet og sosioøkonomisk status har vært bygget på feil premisser. I denne avhandlingen har jeg derfor satt spørsmålstegn ved måten forskning på fysisk aktivitet vanligvis foregår på, og sett på om disse framgangsmåtene i seg selv har betydning for hvordan man forstår sammenhengen mellom fysisk aktivitet og sosioøkonomisk status. Resultatene viste at når forskere har rapportert at grupper med høy sosioøkonomisk status er mer fysisk aktive enn de med lavere sosioøkonomisk status, så har de oftest målt den fysiske aktiviteten som foregår på fritiden, og ikke den som foregår i hjemmet, på jobb, eller som transport. I de tilfellene der jobbrelatert fysisk aktivitet er målt, er det enten ingen forskjell, eller de med lavere sosioøkonomisk status er mer fysisk aktive. Videre fant vi at det kan være relevante sosiale forskjeller både i fysisk aktivitetsvaner målt med dagbøker og i aktivitetserfaringer identifisert gjennom intervju, selv om det ikke alltid er forskjeller i totalt fysisk aktivitetsnivå. Vi så også at når pasienter gis et treningsopplegg i tillegg til vanlig brystkreftbehandling for å se om treningen har en effekt, så vil noen ha vanskeligheter med å gjennomføre alt. Blant annet fordi færre pasienter med lavere sosioøkonomisk status deltar i slike forsøk, er det imidlertid vanskelig å avgjøre om gjennomføringsgraden har sammenheng med sosioøkonomisk status eller ikke. Dog var inntektsnivået litt høyere blant de pasientene som gjennomførte opplegget enn hos de som trakk seg helt. For å komme fram til resultatene har vi gransket 56 publiserte vitenskapelige artikler, sammenlignet tre ulike målemetoder for fysisk aktivitet i en gruppe brystkreftoverlevere, og analysert treningsoppmøtet i en klinisk studie av nyopererte brystkreftpasienter. Avhandlingen konkluderer med at fysisk aktivitetsforskning har en tendens til å ha et ensidig fokus på den fysiske aktiviteten som foregår på fritiden, og at den kan stå i fare for å forsterke forskjellene og favorisere grupper med høyere sosioøkonomisk status.

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Abstract

While social inequalities in health persist, a growing field of physical activity research continues documenting the positive effects of physical activity on mental and physical health. Hence, studies have suggested that there might be an association between physical activity and socioeconomic status. However, public physical activity interventions targeting low socioeconomic groups have shown limited effects, and the associations between physical activity and socioeconomic status seem more complex than previously assumed. Besides, recent research has given reason to believe that there may be practices within the knowledge production in physical activity research as such, that may cause incomplete knowledge about how these variables relate.

The present thesis illuminates the implications of methodological practices within physical activity research as explanations of the reported differences in physical activity between socioeconomic groups. The main question is whether conventional methodological choices affect the reported physical activity in socioeconomic groups differently. In addition to traditional analyses of socioeconomic differences in aspects of physical activity, Papers I-III study the impact of applying various conceptualisations of physical activity, the impact of variations across instruments for collecting physical activity data, and the generalisability of a controlled physical activity intervention across socioeconomic groups, respectively.

The three studies included in the thesis employ different designs. The first paper is a systematic article analysis of 56 previously published papers examining the relationships between physical activity and socioeconomic status, aiming to determine whether findings are linked only to the activity domain investigated, and perhaps not total physical activity. Paper II has a cross-sectional design, applying questionnaires, activity logs, and interviews among 52 breast cancer survivors to uncover possible limitations in standard physical activity questionnaires. In Paper III, we analyse adherence rates in a physical activity treatment intervention among 47 newly diagnosed breast cancer patients to identify socioeconomically (among other) predictors.

The findings suggest that there is evidence for a positive relationship between physical activity and socioeconomic status only for leisure-time physical activity. The positive relationship between the mentioned variables is absent, or negative, in other physical activity domains - especially within the occupational physical activity. In the study of long-term breast cancer survivors, alternative methods assessing physical activity, particularly time-geographic activity logs, reveal socioeconomic differences in experiences from-, and routines for-, physical activity, without there necessarily

being different amounts of total physical activity. In the study of newly diagnosed breast cancer survivors, we found a higher income among those who completed the physical activity intervention comparing to those who withdrew, although there was no significant association between socioeconomic status and adherence rate. A lack of socioeconomic sample representativeness may, in part, explain the lack of associations between adherence rates and socioeconomic status in our material.

The scientific understanding of the relationship between physical activity and socioeconomic status seems to be largely based on exercise and leisure-time physical activity data. The use of traditional questionnaires yields insufficient information about differences in physical activity between socioeconomic groups. It is unclear whether exercise interventions in breast cancer treatment are equally suitable to all socioeconomic groups; however, they may risk excluding lower socioeconomic groups and thus reduce the external validity.

Sammendrag

Parallelt med vedvarende og økende sosiale helseulikheter, dokumenterer et voksende forskningsfelt de positive effektene av fysisk aktivitet på fysisk og mental helse. Studier har derfor antydet en mulig sammenheng mellom fysisk aktivitetsnivå og sosioøkonomisk status. Offentlige tiltak rettet mot grupper med lavere sosioøkonomiske status har imidlertid vist seg å ha begrenset effekt, og sammenhengen mellom fysisk aktivitet og sosioøkonomisk status virker å være mer kompleks enn tidligere antatt. På bakgrunn av senere studier kan det også være grunn til å anta at det kan være elementer i fysisk aktivitetsforskningen som sådan som kan forklare den usikre kunnskapen om sammenhengen mellom sosioøkonomisk status og fysisk aktivitet.

Denne avhandlingen belyser metodisk praksis i fysisk aktivitetsforskning og studerer mulige implikasjoner av slik praksis for den vitenskapelige forståelsen av sosioøkonomiske forskjeller i fysisk aktivitet. Hovedspørsmålet er hvorvidt konvensjonelle metodiske valg påvirker rapportert fysisk aktivitet i ulike sosioøkonomiske grupper forskjellig. Parallelt med tradisjonelle analyser av sosioøkonomiske forskjeller i ulike aspekter ved fysisk aktivitet, studeres henholdsvis betydningen av å bruke ulike operasjonaliseringer av fysisk aktivitet, betydningen av variasjon i instrumenter for måling av fysisk aktivitet, samt generaliserbarheten av en randomisert kontrollert fysisk aktivitetsintervensjon på tvers av ulike sosioøkonomiske grupper.

De tre inkluderte studiene benytter ulike metodiske design. Det første arbeidet er en systematisk analyse av 56 tidligere publiserte artikler om sammenhengen mellom fysisk aktivitet og sosioøkonomisk status, der vi undersøkte hvorvidt funnene i disse studiene kan ha vært knyttet kun til noen avgrensete aktivitetsdomener framfor total fysisk aktivitet. Det andre arbeidet er en tverrsnittstudie blant 52 brystkreftoverlevende der vi brukte spørreskjema, aktivitetslogg og intervju for å belyse begrensninger i standard spørreskjemaer. I det tredje arbeidet analyserte vi gjennomføringsgraden i en fysisk aktivitetsintervensjon hos 47 nylig diagnostiserte brystkreftpasienter, for blant annet å identifisere mulige sosioøkonomiske forklaringsvariabler.

Studienes resultater viste at den positive sammenhengen mellom fysisk aktivitet og sosioøkonomisk status bare gjelder fysisk aktivitet på fritiden. For andre fysisk aktivitetsområder, særlig yrkesrelatert fysisk aktivitet, er sammenhengen fraværende eller negativ. Blant brystkreftoverlevere viste intervju-, og særlig aktivitetslogg-data forskjeller i opplevelser av og rutiner for fysisk aktivitet, uten at det nødvendigvis er

forskjeller i total fysisk aktivitet. I studien av brystkreftpasienter var inntekten høyere i den gruppen som fullførte en aktivitetsintervensjon enn i den gruppen som trakk seg, selv om det ikke var signifikant sammenheng mellom sosioøkonomisk status og graden av gjennomføring i hele intervensjonen for øvrig. Lav sosioøkonomisk utvalgsrepresentativitet viste seg imidlertid å kunne bidra til å forklare den manglende sammenhengen mellom gjennomføringsgrad og sosioøkonomisk status.

Den vitenskapelige forståelsen av sammenhengen mellom fysisk aktivitet og sosioøkonomisk status er i stor grad basert på data om trening og fysisk aktivitet på fritiden. Ensartet bruk av tradisjonelle spørreskjema om fysisk aktivitet på fritiden kan gi begrenset kunnskap om viktige forskjeller i fysisk aktivitet mellom sosioøkonomiske grupper. Det er også usikkert om treningsintervensjoner i brystkreftbehandling er like godt egnet for alle sosioøkonomiske grupper. Slike studier kan risikere å delvis ekskludere grupper med lavere sosioøkonomisk status, og dermed også redusert ekstern validitet.

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NORWEGIAN CANCER SOCIETY

Ragna Stalsberg
Trondheim, February 2021

List of Papers

I. Stalsberg, R. & Pedersen, A.V. (2018). Are differences in physical activity across socioeconomic groups associated with choice of physical activity variables to report? *International journal of environmental research and public health*, 15(5), 922,1-23.

II. Stalsberg, R., Eikemo, T. A., Lundgren, S., & Reidunsdatter, R. J. (2019). Physical activity in long-term breast cancer survivors–A mixed-methods approach. *The Breast*, *46*, 126-135.

III. Stalsberg, R., Bertheussen G.F., Børset H., Thomsen S.N., Husøy A., Flote V.G., Thune I., Lundgren S. (2021). Do breast cancer patients manage to participate in an outdoor tailored physical activity program during adjuvant breast cancer treatment? *Submitted for publication.*

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1. Introduction

Social health inequalities have been on the political agenda for decades. When the well-known Black report was published in Britain in 1980 [1], it showed that the unequal distribution of poor health and death had increased, despite the ambition of the National Health Service in 1948 [2], aiming at good healthcare available to all regardless of the ability to pay. In its aftermaths, although there has been an increased international focus and comprehensive scientifically based public effort aiming at greater social equality in health, international public reports worldwide have concluded that the social inequalities related to health are still attributable to socioeconomic variables, such as income, education, housing, employment and working conditions [3-5]. The paradox of the persistent and widening health inequalities in the welfare states of Western Europe [6] demonstrates that this is an issue of global relevance.

As part of public health in general, physical inactivity is a growing concern because it significantly contributes to noncommunicable, severe diseases, such as stroke, diabetes and cancer [7]. Conversely, physical activity has shown a positive dose-response effect on premature mortality and on the prevention of several mental [8] and physical conditions [9,10]. There seems to be a positive relationship between physical activity levels and socioeconomic status; however, the basis for and the nature of this association is debated [11,12]. Nevertheless, increased physical activity has been a political priority throughout the past 20 years, intensifying health promotion actions and physical activity related research. In 2005, the Norwegian government set a national goal of increasing the number of adults who are active for at least 30 minutes per day [13]; however, despite governmental finances allocated to health promotion actions to increase the physical activity levels of all social groups, it seems that individuals who themselves report that they are being physically inactive are less supportive of such policies [14]. Systematic reviews of studies investigating the effectiveness of physical activity interventions targeting lower socioeconomic groups support these results as the effects are small and do not seem to persist over time [15,16]. Hence, the relationship among socioeconomic status, physical activity and health is not fully understood, generating grounds for new perspectives.

The origin

The idea behind the present thesis originates from a systematic literature review, which was published in 2010 with the present author as a co-author [17]. In that work, we studied the relationship between socioeconomic status and physical activity among adolescents. We found that of the 62 included scientific studies, 58% reported that adolescents with higher socioeconomic status were more physically active than adolescents with lower socioeconomic status; however, the results were not as clear as they seemed. Besides the bias associated with published articles, often tending to present positive before negative results, in fact, 42% of the articles included reported either a negative, or no, tendency towards a socioeconomic difference in physical activity levels among adolescents. In addition, we found an inconsistent usage of measures of both socioeconomic status and physical activity, which complicated interpretations of any findings, while at the same time supported the claim that there may be more than one explanation for possible differences in physical activity levels. Moreover, we found that what was reported as high physical activity levels in the included studies was mostly leisure-time physical activity. The latter point has been recognised as a serious bias in other reviews as well [11,12] and was also illuminated in a commentary to our review [18]. The problem was that other physical activity domains, such as active transport, occupational physical activity and housing and gardening, seemed to have been largely overlooked in previous analyses, and hence the total physical activity level has not, in fact, been measured. The question regarding the relationship between socioeconomic status and physical activity must therefore still be answered.

A second point addressed in the abovementioned comment [18] was the tendency that physical activity research has been biased by a Westernised, developed world perspective. The fact that physical activity researchers have studied variables that are relevant for people in developed countries has resulted in an unrepresentative image of the field, and thus the findings have been less relevant for developing countries. Hence, assuming that physical activity research has an overwhelmingly focus on exercise and leisure-time physical activity and that leisure-time physical activity is unequally distributed across socioeconomic groups, the results from such studies might be less relevant for low-socioeconomic groups as well regardless of their geographical affiliations. Consequently, much research within the field of physical activity benefits high socioeconomic groups, thus likely assisting in

increasing rather than diminishing the growing health inequalities across socioeconomic groups.

The initial motivation for writing this thesis was therefore directed towards scrutinising previously published research on socioeconomic differences in physical activity in the adult population to determine whether the assumed positive relationship between these variables in fact may have been overestimated because most papers within this research field have reported data on leisure-time physical activity. In this case, research, possibly ignoring other domains of physical activity, such as occupational physical activity and physically active transport (bicycling, walking), and household physical activities, including gardening, would exclude important elements of being physically active and would lead to misrepresentations of facts of physical activity levels across socioeconomic groups. As a follow-up, I aimed to examine whether different measures of physical activity, i.e. different methods assessing data on different aspects and domains of physical activity, could assist in better identifying distinctions in physical activity practices between socioeconomic groups and thereafter to identify whether different socioeconomic groups are in fact unequally able to complete traditional physical activity interventions set up for treatment purposes. From there, an interest in the representativity of physical activity trials across socioeconomic groups emerged.

The case

The issues addressed throughout this thesis may apply to a larger area of health research. In this sense, physical activity research could serve as an example wherein the mechanism of the possibly socially biased research takes place. Physical activity research spans a wide variety of topics, be it performance improvement in top athletes, physical activity levels in population groups or possible health effects in patient groups. From a social health inequality point of view, the breast cancer population is an interesting study case because women with higher education levels seem to have benefited more from medical improvements than women with lower education levels. While the breast cancer mortality rates have increased in European women in low-level education groups aged 30–49 years [19,20], the survival rates have shown an improvement for Norwegian patients at the same age in the high socioeconomic status group [21]. Social inequality in health has been targeted by Norwegian health policy strategies in general

[22,23] as well as in policies for cancer prevention and treatment [24,25]. Thus, as ongoing research on physical activity and various breast cancer outcomes seems to yield fruitful results, it is important to ensure that this branch of medical improvement does not primarily favour the most resourceful patients.

Perspectives

As I am basically a sociologist, the thesis is coloured by perspectives from the sociology of health. The perspective of social health inequality is likely obvious. Because the thesis deals with scientific knowledge production, it also touches upon the sociology of scientific knowledge; however, it is not the intention to take on the theoretical perspectives of knowledge production, as such, beyond discussing specific elements, which, directly or indirectly, may be beneficial or disadvantageous for different socioeconomic groups and thereby may contribute to increasing social inequalities in health. Moreover, the discussion is limited to the specific area dealing with knowledge production within physical activity research. The hypothesis that physical activity research is at risk of being most beneficial to individuals with higher socioeconomic status may—if proven to be true—complement prevailing theories of social inequality in health. The paper 'The Inverse Health Care Law' uncovered structures of medical care distribution in Britain between 1930–70, stating 'the availability of good medical care tends to vary inversely with the need for it in the population served' [26] (p. 7696). Similarly, the present thesis deals with a possible inverse physical activity research law.

The purpose

The overall purpose is to illuminate possible implications of physical activity research practice for the scientific understanding of differences in physical activity between socioeconomic groups. A central question is whether methodological decisions in measuring physical activity may affect reported physical activity behaviours differently between socioeconomic groups.

2. Background

Social inequalities in health

The terms social 'health inequality' and social 'health inequity' are used interchangeably in the literature to describe disparities within aspects of health across social groups. While 'equality' in the context of health describes the situation in which everyone receives the same treatment regardless of their starting points, the idea of 'equity' produces a type of fairness by giving each individual what they need to succeed [27]. Both terms are relevant in the present work, albeit which one is the most apt definition has been extensively discussed. For example, based on Whitehead's working definition of health inequity, *'...differences in health which are unnecessary and avoidable but, in addition are also considered unfair and unjust'* [28] (p.220), Braveman suggested the following: *'... a particular type of difference in health or in the most important influences on health that could potentially be shaped by policies; it is a difference in which disadvantaged social groups (...) systematically experience worse health or greater health risks than more advantaged groups'* [29] (p.180). The latter definition accentuates mechanisms progressing through policy making and thereby suggests an accountability of significant policymakers.

The World Health Organisation (WHO) still refers to Whitehead's definition [30], stating that *'..."equity in health implies that ideally everyone could attain their full health potential and that no one should be disadvantaged from achieving this potential because of their social position or other socially determined circumstance'* (p.5). The social determinants of health are further described as *'the circumstances in which people are born, grow up, live, work and age, and the systems put in place to deal with illness.* These circumstances are in turn *'shaped by a wider set of forces: economics social policies, and politics'* [31]. Thus, the WHO recognises the importance of social structures and consequently mitigates individuals' responsibility for their own health.

A piece of evidence

Much evidence of health differences across socioeconomic groups exists [32], though the degree of inequality varies across countries. For example, according to a summary from the organisation for economic cooperation and

development (OECD) countries in 2019, a six-year average difference in life expectancy between the highest and the lowest educated has been reported [33]. In addition, across these countries, twice as many men and women from the lowest educational group are daily smokers compared to the highest educational group [34]. Furthermore, there was an average difference in overweight and obesity rates at 36 versus 52% for women and 54 versus 58% for men between the highest and the lowest educational group in 2017, respectively [35]. Other examples include inequalities in access to healthcare, in the positive relationship between income level and visiting a general practitioner or a specialist and an association between unmet medical needs and low income [33].

In Nordic countries, in which welfare politics are considered universal and generous to all social groups, continuous socioeconomic differences in mortality rates have been confirmed [6,36-38]. For instance, in the period from 2005–2015, the difference in life expectancy between the richest (1%) and the poorest (1%) Norwegians was 13.8 and 8.4 years for men and women, respectively [39]. Other studies of social health inequalities in Norway have shown that having lower education increases the risk of dying from cancer [40,41], suffering from chronic obstructive pulmonary disease [42,43], experiencing [44] and dying from heart attack [45] and being injured or involved in severe accidents [46].

Social inequalities in health could be analysed on various levels and/or could include all kinds of disadvantaged groups. The research covered in the present thesis is limited to the relationship between physical activity and socioeconomic status (mostly), including individual-level indicators, such as income, occupation, education or possible proxies of such; however, it is important to emphasise that using socioeconomic status as an explanatory variable in health research is not straightforward.

Socioeconomic status

It is widely agreed in the literature (e.g.[47-50]) that there is no single best indicator of socioeconomic status that suits the purposes of every health study [51]. As also observed in the point-of-departure review referred to in the introduction [17], there are many ways to measure socioeconomic status. Different indicators often correlate because they measure different dimensions of the same socioeconomic stratification. Nevertheless, to

analyse and to understand socioeconomic inequalities in health, conceptual clarity regarding which socioeconomic parameters are being measured and why is required [49,52].

To understand the concepts underlying the use of socioeconomic status in health research as such, it is necessary to first account for their origins [52]. Two of the most dominant theories of how society develops social systems from individuals' socioeconomic conditions are the Marxist and the Weberian theories. In the Marxist theory, socioeconomic status is determined by 'social class', whereby individuals are defined by their relation to the 'means of production' (i.e. land, factories) [53,54]. The relationship between the exploiting owners and the exploited workers creates the two major, opposing social classes (the bourgeoisie and the proletariat) within a social structure that is actually composed of several classes [54]. Hence, the essence of the Marxist theory is individuals' relation to the means of production more than status or income inequalities. According to Krieger et al., Wright's class scheme is an exceptional representative of epidemiological research of a classification based on Marxist social class theory, including ownership of capital assets, control of organisational assets and possession of skills or credential assets [49].

An alternative view on social stratification, which places more emphasis on human agency compared to the Marxist structural approach, is the Weberian class theory of a hierarchical stratified society. Weber argued that a 'social class situation' of an individual reflects market-determined 'life-chances' that are based on resources, such as property, skills and education [54]. Individuals within different social groups share common positions with similar life possibilities. These possibilities, or 'life chances', are created by individuals through the trading of resources in a market. Depending on the amounts and types of resources they bring to the market, individuals are characterised by a position in the market, which thus determines their 'life chances'.

In addition to the obvious purpose of describing the social pattern of diseases, socioeconomic status is used to explain the causal mechanisms of social health inequalities as well as to adjust to socioeconomic conditions when other health-related variables are the primary aim [53]. In general, occupation, income and education are the most commonly used individual-level indicators of socioeconomic status; however, due to traditions and differences in the dominant societal structures, they have been given different

emphasis in different countries. For example, according to Galobardes, because people's occupations are recorded systematically on all death certificates in the United Kingdom, occupation-based indicators are widely used. Occupation-based indicators are considered to represent Weber's notion of socioeconomic status because a person's occupation can either reflect his/her position related to social standing, income and intellect; characterise relations between persons as employers and employees; or in the context of social classes, possibly characterise people with different occupations as either exploiters or those exploited [51]. Because an occupation-based indicator may be used as a measure of social relations, networks and prestige, independent work and authority, or rather, people's lifestyles, occupational status can provide information regarding social inequalities that may affect people's health status [51,52].

The occupational class-scheme of Goldthorpe et al. is one example of how socioeconomic status is constructed as an occupation-based measure based on the individuals' working and market situation, capturing a person's level of job control, work independence and authority [55]. Other examples are the International Standard Classification of Occupations (ISCO) (prepared by the International Labour Organisation), which is the basis for the Nordic Classification of Occupations (NYK), the Standards of Swedish Classifications of Occupations (SSYK) and the Danish version of the ISCO (DISCO). The relatively easy access to occupational data is an important strength of using such indicators [51], whereas classification challenges, such as of people permanently or temporarily outside the labour force, represent a limitation in using occupational measures of socioeconomic status. One example would be the group of old-age pensioners, who have retired from work and therefore may be classified as outside the workforce but who possess a wide variety of other resources that make the classification of these elderly persons much more complex. Hence, Grundy and Holt suggested a combination of indicators to measure socioeconomic status in elderly populations [56].

As opposed to the British tradition, socioeconomic status is often equated with income in studies conducted in the United States [48]. Obviously, income and wealth are the most direct measures of individuals' material conditions, and thus they influence health-related issues that require material resources (e.g. medication, sport club membership, healthy food, access to services, etc.) [51]. They also influence people's educational possibilities and access to certain lifestyles and prestige, which are factors associated with

better health [52]; however, personal income appears to be a sensitive issue in some populations, from which some individuals may be reluctant to provide such data. Another challenge in collecting income data is that fluctuations in income over time and informal work could render a misleading rank of household wealth [57]. In this sense, occupational data may be more stable. Household assets, amenities or housing tenure have been suggested as alternative measures as they may represent a convenient way to describe the living standards of a household; however, the limitation of such measurements is that they may hold only for the context in which they were developed, and thus they are difficult to compare across studies [51].

Because an individual's level of education is considered to capture the resources related to his/her knowledge, education is frequently used as a generic indicator of socioeconomic status in epidemiological studies [53]. Education represents one of the Weberian status domains influencing lifestyle and social relations/networking, which in turn is associated with better health. Blane [58] outlined five possible processes through which education is linked to better health. First, the material and cultural circumstances during childhood, which are influenced by parental socioeconomic status, may influence an individual's educational attainment and personal adult health. Second, as educational attainment is related to adult occupation and income, adult health is influenced by the social circumstances in adulthood intermediated through educational attainment. Third, educational level may influence how public health advice is understood due to sometimes complex language in messages or because the educated possess the resources needed to adapt their behaviours. Fourth, other background variables, such as self-efficacy and preferences, could influence both the capacity to complete higher levels of education and to cope with diseases. Fifth, poor childhood health can affect educational attainment negatively and can also influence longevity. The strengths of using education as an indicator are that it is easy to measure, it is applicable to persons outside the work force and it is stable throughout the life course. On the other hand, because there have been large changes in the educational systems and opportunities for educational attainment in many countries over time, possible cohort effects could occur [51].

An important question in operationalising socioeconomic status relates to the units of analysis and whether the individual or the entire household should be included [52]. The total amount of resources held within a family unit can be considered to contribute to a resource pool, from which all family

members benefit in the market that determinates social positions. This is an important question when women are the subject of analyses because their social status has traditionally been determined by the social standing of her spouse or father. In the previously mentioned procedure for death certificates in the UK, the way women's occupational status was stated as either daughters, wives or widows serves as an illustration [59]. The fact that families in contemporary societies often consist of persons belonging to different occupational classes may point towards the household as the relevant unit of analysis. On the other hand, the increasing number of lone parents indicates that social classification could be determined by the most dominant occupation in the household [54]. Erikson's conception of occupational dominance order [60] describes such a way of ascribing class position to families.

Indicators of socioeconomic status may also interact with ethnic groups and may differ across countries and age groups, thus producing complex results, albeit the race/ethnicity dimension is most pertinent for American studies. According to Williams et al., all indicators of socioeconomic status are patterned by race. For example, Asians living in the US have a high socioeconomic status compared to (non-Hispanic) whites, particularly in terms of educational level, and whites households are significantly more wealthy than Asian, black and Hispanic households [50]. In sum, using a single or only a few indicators of socioeconomic status in analyses of social inequalities in health could hamper the understanding of how socioeconomic status is related to health.

To capture the construct of unequal access to desired resources, some researchers prefer the term 'socioeconomic position' rather than 'socioeconomic status' because prestige-related characteristics in the first refer to the relative position in the social hierarchy, while the latter is considered to not distinguish between actual resources and status [49]. Nevertheless, as it appears to be the most widely used concept in health research, socioeconomic status is used in the remainder of the present thesis.

Explanations of social inequalities in health

The complexity of socioeconomic status measures possibly reflects that there is no single explanation for social health inequalities. The increased evidence of social inequalities in health has given rise to a number of theories

regarding why social health inequalities exist and why they seem to widen. One overview of theories is provided by Mackenbach [61] for the purpose of explaining the persistence and widening of health inequalities in welfare countries. Some of these theories are outlined to possibly support the hypothesis of social inequity in physical activity research.

Causal explanations of social inequalities in health include the traditional social determinant view that social position affects health. Material disadvantage and poor access to important health-giving resources, such as unpolluted water, healthy and nutritious food or adequate resting time, in addition to poor environmental living or working conditions, including heavy traffic or the discharge of toxic substances, are socially unevenly distributed [62]; however, the evidence that the probability of good health increases linearly with increased socioeconomic status, and is not merely a matter of differences between the poorest and the richest [33,63], has led to new theories of health behaviours and lifestyles. A relevant example is Bourdieu's theory of practice [64,65], which describes how individuals' health-related habits and actions are influenced by the social conditions under which they live. In the theory of practice, social classification refers to the material conditions that contextualises people's daily life, and in so doing, shapes these people's ways of habitual acting. Habitus reflects the unconscious process that acts as a managing instrument within everyone's body when values and habits that are characteristic of individual's social class are incorporated into his/her body and translated into corporeal knowledge. The choice of a healthy behaviour is thus a result of an individual's (unconsciously working) habitus. The habitus of an individual is more alike the habitus of an individual of a similar social classification compared to the habitus of someone of a different social classification. Hence, the social practice of health behaviours among individuals of one social classification differs from the social practice of health behaviour among individuals with another social classification.

In addition, because the relationship between socioeconomic status and health outcomes cannot be explained as caused solely by material disadvantage, intelligence has been introduced as a possible elusive fundamental cause of social inequalities in health [66]. Rooted in Lieberson's concept of basic causes [67], the idea of a fundamental cause of health inequalities was later introduced by Link and Phelan [68-71]. The theory describes that individuals with higher socioeconomic status possess a set of important and flexible resources, such as knowledge, power and economic as well as social capital, which protects them from disease and death regardless

of the point in time and the health challenges that are characteristic of that period. Because individuals of lower socioeconomic status possess fewer of these resources, they are more exposed to disease and death regardless of which time they live in. For example, people of higher socioeconomic status to a larger extent take advantage of advanced medical screening techniques, vaccines or other medical innovations, likely because they have the knowledge and the types of capital needed to adapt to the changes. In the case of physical activity, Link and Phelan exemplified that the notion of 'the good life' in high socioeconomic groups has changed from the freedom from physical labour and sedentary activities into the habits of visiting well-appointed health clubs [70]. Mechanisms like the ones described are claimed to contribute to persisting health inequalities and explain why social health inequalities persist even when proximal decisive risk factors, such as polluted water or tuberculosis, are eliminated [68-71].

Later, Strazdins et al. [72,73] suggested availability of time as an additional health resource. As time scarcity may function as a barrier to healthy behaviour, such as physical activity, preparation of healthy food or building supportive relationships, people experiencing time constraints are more prone to poor health. The reason for such differences is that time scarcity may be socially patterned. For example, lone parents must spend more time on caring compared to paired parents, and people with low income are not able to attenuate their time deficit by paying for services. In addition, incorporating time-geography theory [74,75], space (closely intertwined with time as moving in space takes time) has a similar impact on health. Low-income families more often reside in city suburbs, and the distance between their home and work, for example, may introduce negative consequences for health as the time-distance requires motorised transport.

Although the problem of interpreting the concepts of equity and fairness in the context of social health disparities has been recognised by many (see for example [29,76,77]), there is no doubt that whichever theoretical explanation is chosen, social inequalities in health are an issue of justice, as stated by Braveman: *'Health disparities adversely affect groups who are already disadvantaged socially, putting them at further disadvantage with respect to their health, thereby making it potentially more difficult to overcome social disadvantage'* [78] (p.152).

Challenges in tackling social inequalities in health

Health inequality is understood not only as poor health of disadvantaged groups but often as a social gradient by which the chances of good health increases linearly with increased socioeconomic status. The health gradient is described as a positive correlation between an individual's health status and his/her level of education, suggesting an increase in educational level to be the most effective health promoting measure [33,63]. With regard to health policies, one debate relates to whether the whole population or a population residuum is targeted [79]. According to Vallgårda [79], the choice of strategy is linked to whether the problem is perceived as a social gradient or as poor health of disadvantaged groups, respectively.

One of the principles for policy action for reducing health inequalities outlined in the technical document of the WHO by Whitehead and Dahlgren [30,80] is to increase the level of health of the social groups that are in a less advantageous position up to the level of the groups that are in a more advantageous position—not to decrease the level of health of the more affluent groups of people. The OECD report referred to in a previous paragraph also acknowledges a need for more tailored political solutions to reduce social health inequalities and addresses the importance of evaluating public health interventions with regard to their ability to in fact reduce practices among the less advantaged that may lead to poorer health [29].

Importantly, health promoting actions should be implemented with great caution as some of the intervention programmes that succeed in improving the health of the population in general have been found to in fact increase social disparities in health. According to Lorenc et al. [81], such effects can be termed 'intervention generated inequalities', a phenomenon that is also recognised by Tugwell, who described how the phenomenon may arise at different points throughout an intervention process [82]. Whereas downstream interventions require voluntary action by individuals and likely increase inequalities, upstream actions at the policy level are less likely to increase social inequalities as they deliver benefits to the disadvantaged aiming at reducing inequity [83]. What seems to happen is described in a paraphrase of the Inverse Health Care Law [26], namely the 'Inverse Prevention Law', which reads: *'those in most need of benefitting from preventive interventions are least likely to receive them'* [81]. In a similar vein, Merrild et al. demonstrated through data from 12 months of field work that among lower-working-class and higher-middle-class informants, the public health discourse in Denmark, which encourages the individual

responsibility for one's own health, is more prevalent among the high compared to low socioeconomic groups and that lower socioeconomic individuals experience more difficulties in complying with all the embedded expectations [84]. In conclusion, Merrild et al. suggested that by ignoring socioeconomic differences in health practices, the health discourse in fact contributes to persisting health inequalities.

The social mechanisms comprised in the concepts of 'intervention generated inequalities' and the 'inverse prevention law' resemble the unintended mechanism observed to occur when new medical innovations are introduced to society. Within the abovementioned theoretical framework of the fundamental causes of inequalities in health [63-66], several studies have suggested that because individuals in high socioeconomic groups have flexible resources, they have easier access to health technologies than individuals with a lower socioeconomic status [85-87], although there is no evidence that such intentions could attribute to either health technology companies or to health services. Analogue to such a perspective is that although health research basically is supposed to serve all social groups, the present thesis suggests that high socioeconomic groups deploy their resources (i.e. money, knowledge, beneficial social networks, time and cultural capital) and therefore benefit from contemporary physical activity research and not merely from the activity itself.

Physical activity across socioeconomic status groups

Large volumes of health research show that physical activity has a positive impact on individuals' mental and physical health as well as on longevity [9,10]. Moderate-to-vigorous physical activity for 150 minutes per week has been associated with considerable health benefits [88], and thus it was included in contemporary national [89] and international [7] public recommendations for physical activity among adults. In the latest update of the WHO guidelines, the reduction of sedentary behaviours for optimal health outcomes is included [90]. Nevertheless, as pointed out by Dahlgren and Whitehead [30], the determinants of health, such as physical activity, are socially patterned. Thus, based on the growing evidence of the effect of physical activity on a wide variety of health outcomes, concurrently with the evidence of increased social inequalities in health, it has become increasingly important to detect social inequalities in physical activity levels.

Assumedly, based on how social inequalities in health in general are understood as consequences of different lifestyles, it has been widely supposed that physical activity is unequally distributed across socioeconomic status in favour of higher socioeconomic groups. Many previous studies appear to have supported these hypothesis [91-95]. Framed by theories of social inequalities in health, the relationship is explained, albeit with varying degrees of profundity. In medical journals, a positive relationship between physical activity level and socioeconomic status is in most cases scarcely interpreted from theoretical perspectives, often due to not being the primary aim of studies. Briefly, the inequality in health that is mediated through physical (in)activity is plausibly explained by a socially unequal distribution of assets or resources that affect people's ability to be physically active (e.g. money, healthy norms, habits, social networks, adaptability, intelligence, knowledge or time). People who possess fewer of these resources, i.e. people with a lower socioeconomic status, are less likely to be physically active, and thus they are at greater risk of having poor health. Improving accessibility to physical activity facilities and increases physical activity levels, and physical activity interventions targeting lower socioeconomic groups have been, with the best intentions, introduced as a result; however, there is evidence that physical activity interventions targeting low-socioeconomic groups have little [15], none or a temporary effect. At the same time, several researchers have questioned the premises for the results emerging from some research investigations of social inequalities in physical activity.

As mentioned, in a review of previous studies published up to 2010, which the present author co-authored, that investigated the association between physical activity and socioeconomic status in adolescents, we concluded, with pronounced reservations, that there might be some relationship between the variables [17]. More than 40% of the papers included in the review reported either a negative or no socioeconomic difference in physical activity levels. A confounding factor was the variability in physical activity measurements across studies and the apparently random usage of physical activity measurements in terms of the type, its duration and frequency, and the intensity of the activity. A geographically conditioned, yet inconsistent use of socioeconomic status measurements across studies, was also observed [17].

In the mentioned commentary that followed, Palma and Assis stated that there was an inaccurate usage of the physical activity term in the bulk of the previously published literature on these matters, including in our paper [18].

Second, they directed attention to a cultural bias in contemporary physical activity research in general as the physical activity that was previously reported by high socioeconomic groups was only the kind of physical activity that is performed during leisure time. Moreover, the commentary called attention to the fact that most researchers within the research area are in fact from developed countries and that they examine variables relevant for people living in these countries [18], thereby accentuating a possible unrepresentativeness in physical activity research across social groups and countries.

The same nuances described in the abovementioned literature have been acknowledged in other studies. For example, Gidlow et al. [11] reported in a 2006 review of the evidence of a positive gradient of increasing physical activity across socioeconomic groups that education was the most commonly used indicator of socioeconomic status and seemed to produce the most stable relationships with physical activity. Later, Beenackers et al. [12] summarised that approximately equal amounts of positive, negative and null associations between socioeconomic status and physical activity among European adults were reported in papers included in their review on the subject. Moreover, they reiterated the tendency that education more often produced significant associations with physical activity levels than the income variable, and they also introduced geographical differences into the evidence. Beenackers et al. [12] also demonstrated that in studies that reported occupational physical activity, low-socioeconomic groups were found to be more physically active and that leisure-time physical activity was the most often assessed domain of physical activity in which high-socioeconomic groups were more active. Thus, the uncertainties in the associations between physical activity and socioeconomic status may be related to methodological issues, and altogether, they constitute a hypothesis of a more complex pattern of the relationship between socioeconomic status and physical activity than previously assumed.

A striking piece of evidence of how the believed true but uncertain knowledge about this relationship (a so-called academic urban legend [96]) is maintained is the fact that most studies citing our review [17] refer to the overall finding that there is a positive relationship between physical activity level and socioeconomic status, thus ignoring our reservations regarding possible methodological implications, which raises doubts about previous research. Because physical activity has a crucial role in the prevention and treatment of many chronic diseases [10], precise measurements of physical

activity is of paramount importance [97]. In addition, because physical activity interventions in rehabilitation and treatment are based on scientific evidence, the research must be detailed and valid across socioeconomic status groups to meet the needs of all socioeconomic groups.

Methodological issues in physical activity research

In general, trustworthy research is associated with whether the propositions, the inference and the conclusions drawn from study results are reliable and valid. Reliability in this case is known as the extent to which the measurements involved are consistent, stable and repeatable [98], meaning the constancy of measurements conducted under different conditions from which (approximately) the same results should be expected. Validity is defined and used differently across various scientific disciplines; however, it always concerns whether researchers can assure that what they measured is what they intended to measure, meaning the extent to which a measurement is an exact representative of what happened [98].

Defining and understanding the physical activity construct

Palma and Assis [18] noted that published physical activity research has applied the term physical activity inaccurately, challenging the construct validity, which concerns the operationalisation of the concept in use. A theoretical definition of a concept or a construct corresponds to what the researchers intended to do, whereas their operationalisation of the concept represents what they actually studied [99]. In the case of physical activity, construct validity is achieved when making legitimate inferences from a study's operationalisation of physical activity (the construct) to the theoretical construct of physical activity on which the operationalisation is based. In other words, the basic theoretical definition of physical activity and how physical activity is operationalised must coincide.

In health-related scientific journals, a most frequently cited definition of physical activity is *'any bodily movement produced by skeletal muscles that results in energy expenditure'* [100]; however, the concept is considered an umbrella term that could be subdivided into the domains of leisure-time physical activity, occupational physical activity, housing, or domestic, physical activity (including gardening, and, for example, vehicle maintenance) and active transport [97] in addition to the residual undefinable,

intangible in-between-activity that is tentatively termed daily-life physical activity (DLPA) [101]. The sum of all physical activity is usually accurately labelled as total, or overall, physical activity.

Actual total activity is difficult to measure accurately without biases related to its constituents [17,97,102]: the type, its frequency (the number of events of activity during a specific period), the intensity (physiological effort associated with participating in a particular type of physical activity) and duration (time of participation in a single bout of physical activity) [97,100,102]. This is particularly difficult because the activity changes from day to day as well as across different seasons [102] and often depends, for example, on weather conditions. To briefly exemplify some of the complexity representing difficulties in measuring accurate physical activity data, the subjective perceptions of intensity and sweat varies much, and the differences in maturity among adolescents and children can be large. Moreover, both walking on a treadmill or an asphalted road without ascent and walking as a heavily packed hiker in stony mountains are both frequently classified as walking but are far from equally physically demanding. Thompson et al. underlined the complexity stating that *'no single metric will reflect an individual's physical activity adequately because multiple biologically important dimensions are independent and unrelated'* [103]. As to the question of validity, all components and dimensions of physical activity must be assessed when the intention is to study whether people are sufficiently active according to the health recommendations. Conclusions about real physical activity levels relative to the health effect are often at risk of being inaccurate [97].

In addition, as frequently emphasised in the literature (e.g. [104-107]) *physical activity* and *exercise* are terms often confused with one another. This seems to be the case in the scientific literature just as much as in the media or in popular science papers. Although scarcely documented, there is evidence to suggest that people often refer to physical exercise when they are asked about physical activity, likely due to said misconceptions. A concept analysis of exercise and physical activity within the nursing literature demonstrated a profound inconsistency in the use of the term *exercise* [106]. In addition, results from an interview study asking African American and American Indian women about the definitions, meanings and interpretations of 'physical activity' revealed that these women considered physical activity to be *exercise* and that they had an understanding of the term *intensity* that differed from that of the researchers [107]. In another qualitative analysis of

health beliefs in Filipino adults, the respondents described different types of unstructured physical activity as exercise [108]. According to Caspersen et al., physical exercise is a subset of physical activity that is *'planned, structured, and repetitive, and has a final or an intermediate objective the improvement or maintenance of physical fitness'* [100]. Because it is restricted to activities that include elements of improvement, or maintenance, of physical fitness, this definition excludes leisure-time activities, such as hiking, going for a walk, non-competitive swimming, skiing or other winter-activities. Ekblom-Bak et al. have suggested designating these activities as non-exercise physical activity (NEPA) [109]. Nevertheless, they are important for the total levels of physical activity.

In most cases, physical exercise is performed during leisure time (at least this is the case for non-professionals) and unless prescribed by a medical doctor for medical reasons, is motivated by an individual desire more than a necessity, contrary to occupational and household activities or active transport to work or to school. Hence, physical exercise is included in the leisure-time physical activity domain. An undue biased research focus on leisure-time physical activity or even solely on physical exercise as a proxy for an individual's total physical activity level would therefore at least result in misrepresentations of physical activity levels among people whose primarily physical activity is performed within other physical activity domains. If the biased focus becomes a widespread and repeated practice within a research field, a mis-representation due to inaccurate premises will eventually stand as the research domain-specific 'knowledge'.

Assessing and measuring physical activity

How we choose to measure physical activity affects which aspects of physical activity we gain knowledge about. Hence, repeatedly assessing physical activity with the same instrument renders invariable results; however, the health effects of physical activity depend on an estimated minimum volume of 150 minutes at a moderate-to-vigorous intensity per week [7]. Physical activity is therefore usually assessed in terms of a quantified level. Besides minutes per time-period in a certain intensity, another frequently used measure is the metabolic equivalents of tasks (METs) [110]. METs refer to the ratio of an individual's metabolic rate relative to her/his resting metabolic rate and is a way of describing intensities of different physical activities. A previous study found a 10-25% risk reduction

for premature mortality for every 1 MET increase [111]. Warburton et al. [88] also emphasise the health effect of small increases in physical activity in inactive individuals. Nevertheless, groups of individuals who exceed the recommended volume of physical activity are usually characterised as 'active' in contrast to the subpopulation groups that are considered at risk. The fact that the health effect is related to a certain dose of physical activity partly explains a comprehensive focus in health-related research of physical activity on the levels of physical activity in preference to other aspects, such as routines of or experiences from physical activity.

A wide range of objective and subjective assessment instruments exist for measuring physical activity levels: observations, doubly-labelled water registrations, accelerometers and pedometers and narratives and diaries as well as other wearable gadgets, such as cameras and watches (see for example [112,113]). The effectiveness of these methods has been debated, and none of the instruments could be considered a real gold standard from which other instruments should be calibrated. The doubly labelled water technique that measures actual energy expenditure during a specific period is often used to validate other physical activity instruments; however, the method is expensive and hence restricted to small study samples [114] and is limited because it measures only one dimension of physical activity [112,115]. The feasibility of questionnaires due to low costs and convenience has therefore made self-reporting questionnaires the most frequently used method in assessing physical activity levels in populations of different sizes [116,117]. If properly constructed, physical activity questionnaires can potentially provide information for all physical activity dimensions, domains and time combinations as well as for the social context in which physical activity takes place [118]; however, the use of physical activity questionnaires is also disputed for a number of reasons.

Validity studies of questionnaires used for assessing physical activity have shown that self-reported physical activity questionnaires underestimate energy expenditure when compared to diaries and overestimate energy expenditure when compared to activity monitoring [113]. Some questionnaires have also been found to overestimate vigorous physical activity when compared to activity monitoring and to overestimate time spent engaging in a physical activity of a certain intensity when compared to measures conducted by heart rate monitors. Self-reported physical activity is often infested with recall and response biases [119], which in turn may result in over-reporting physical activity levels [116,120]. A systematic review of

measurement properties showed that of 85 versions of physical activity questionnaires included, 62 had insufficient content validity in that they did not measure both activity duration and frequency and did not cover all relevant physical activity domains [121]. The latter finding supports a tendency pointed out in Beenackers et al. that only 10 of 131 studies included in their review reported on the occupational physical activity domain [12]. According to a literature summary in Nigg et al. [118], questionnaires are also less sensitive to behavioural changes and suffer from the abovementioned problem of misconceptions, including difficulties in distinguishing between exercise and other types of physical activity as well as variations in the perceptions of effort. In addition, there are the problems with social desirability reported for questionnaires in general, which appear to be amplified in physical activity reports [122]. Moreover, Nigg et al. point to the fact that because physical activity as a concept can be understood differently across age, gender and cultures, serious misconceptions can result from the results of physical activity questionnaires [118].

Studies of physical activity levels, including studies investigating socioeconomic differences in physical activity, are commonly based on a physical activity definition, such as the one of Caspersen et al. referred to previously [100]. Nevertheless, according to Rowe, this highly cited definition masks the complexity of physical activity as physical activity incorporates behavioural, physiological and biomedical variables [112]. Rowe further argued that information about the environmental context in which physical activity takes place is critical for understanding why some individuals take part in physical activity (and others do not). In a theory paper, Bussman and van den Berg-Emons also illuminated the influence of what they called quality parameters of physical activity behaviours, such as speed, symmetry, stability and spatio-temporal parameters [123]. In sum, physical activity questionnaires in general are beset with a number of validity issues and have clear shortcomings in that they usually do not measure other aspects of physical activity than the quantitative amount, or level, in addition to the limited number of physical activity domains.

If the purpose of physical activity data acquisition is to build foundations on which to introduce public interventions targeting subpopulations at risk, multiple measuring methods, including physical activity questionnaires, are suggested to capture all physical activity domains and to uncover important distinctions between subgroups [118]. If questions about physical activity are always asked in the same way, data may simply confirm previous

assumptions about physical activity across social groups. In addition, if people tend to misinterpret physical activity in questionnaires, the responses are likely to refer to leisure-time physical activity (or exercise) regardless of researchers' attempts to include other domains of physical activity in the set of questions. A study by Bredland et al., which utilised physical activity-logs for assessing physical activity data, may serve as an example of the usefulness of alternative methods. The study showed that older men's daily-life activities, which otherwise would not have been registered in a traditional physical activity questionnaire, could account for equally or a larger amount of METs per week of what is recommended for formal exercise [124]. Furthermore, physical activity-logs could provide data on the distribution of sedentary time and physical activity bouts, which is found to be equally relevant to health as the amount of physical activity alone [88,123]. Although it is an epistemological question taking the bio-psychosocial perspective [125], physical activity may also be understood as a culturally determined, subjective social practice that affects other important aspects of people's health, and hence including qualitative data might yield further information useful in understanding the complexity of physical activity behaviours.

Including and excluding participants in physical activity intervention studies

A consequence of the considerable evidence of the associations between physical activity and health is an increased number of physical activity intervention studies. The purposes of these intervention studies are, of course, to investigate the effect of a detailed physical activity programme on specific health outcomes. The most common intervention programmes consist of moderate-to-vigorous physical exercise, although lower-intensity programmes are sometimes provided among some patient groups or in elderly populations. Nevertheless, the typical randomised controlled trial (RCT) design has been criticised for poor real-world relevance and limited generalisability due to strict inclusion and exclusion criteria [126,127].

Internal validity refers to whether observed changes after intervention completion (i.e. the effects of specific variables, such as decreased BMI after exercise) can be attributed to the methods in use and not to other confounding causes [128]. This justifies the need for homogenous samples in clinical RCT studies as the confounding factors must be kept constant [129]. Internal validity is therefore relevant in studies that assess the effect of an

intervention, such as for a physical activity programme. To claim valid conclusions about possible effects of a physical activity intervention programme, systematic errors that arise through selection bias, performance bias, detection bias or attrition bias should be avoided [130]; however, most pertinent of the present discussion is sample/inclusion bias and attrition bias. Studies examining the effect of a physical activity intervention in a population of patients will suffer from inclusion bias if, for example, most of the individuals who volunteer to participate are above averagely physically active at the time of inclusion. In the case of social misrepresentation, inclusion bias occurs if the sample is dominated by participants with a higher socioeconomic status. Conclusions drawn about the effect of the intervention programme may be considered erroneous in these cases due to the confounding effects of a homogenous research sample.

The relationship between inclusion bias and *external validity* involves generalisation and the extent to which the results from a study are realistic and hold for other situations or other social groups [128]. In general, strict eligibility criteria in RCTs are essential but also exclude many subjects from participating. A previous literature review of 52 pharmaceutical studies within cardiology, mental health and oncology, providing comparative analyses of adult patient samples from RCTs and adult patient populations treated outside the RCT setting, showed that 71% of the studies had poor external validity because high proportions of the general population with the specific disease were excluded from the trial [131]. The historical debate about the shortcomings of external validity was reproduced in Epstein's *Inclusion – The Politics of Differences in Medical Research* [132]. Because the ideal clinical trial studies 'standard humans', they are not representative of the population of interest in terms of the characteristics of the participants. According to Epstein, this has been considered unfair because assuming the trial provides treatment access, excluding groups of individuals could be considered an unjust distribution of treatment. In addition, results from studies in which 'non-standard humans' are underrepresented cannot be generalised to 'nonstandard' humans. For RCTs that provide evidence of treatment effects from, for example, an exercise programme, the results may not be applicable in clinical practice; however, according to Rotwell, researchers, ethics committees, medical journals, governmental regulators and others frequently neglect external validity, and hence the clinicians are left to decide what is best for each patient [133]. Although Epstein described a shift towards an 'inclusion-and-difference' paradigm between the late 1980s and the late 1990s, which acknowledges the significance of human

diversity in trials, there are still reasons to be aware of the pitfalls of strict inclusion and exclusion criteria.

The threat to internal validity from *attrition bias* is pertinent to physical activity research and concerns participants' inclination to follow a prescribed or agreed dose of physical activity (that is, the activity performed for a predefined *duration* at a certain *frequency* and with an appropriate *intensity*). Such behaviour has been designated, although thoroughly debated, as (physical activity) *compliance*, *adherence*, *persistence*, (*fidelity*), *maintenance* or *concordance*, all attempting to describe the same construct [134-137]. These terms have been operationalised differently in the literature [135,138,139]. The term *persistence* is associated with the duration of an intervention programme and is—like the terms, *fidelity* and *maintenance*—not as frequently used compared to the remaining terms. To avoid the paternalistic connotations and dichotomous qualities embedded in the term *compliance*, while at the same time being less concerned about the process of discussions between patient and prescriber, which is conceptualised in the term *concordance*, the term *adherence* is preferred in the present thesis.

Adherence is defined by the WHO as '*the extent to which a person's behaviour […] corresponds with agreed recommendations from a health care provider*' [140] (p.3) and must be properly recorded for the reported effect of an experiment involving physical activity to be deemed valid. Several factors contribute to variations in the reporting of adherence rates across trials, including how the concept itself is defined and operationalised. Considerable variations of the term *adherence* exist in the literature: a total number of exercise sessions attended or a percentage of the amount of prescribed exercise; a percentage calculated from the number of sessions patients expect to attend based either on the individual treatment protocol or a patient's goal; an average of minutes in physical activity relative to the maximum number of physical activities possible according to the intervention protocol [141,142]; attendance rates plus compliance to exercise intensity and duration according to the intervention protocol [143]; the percentage of participants who comply with the intervention programme in terms of a pre-decided minimum of attendance (in this case: ⅔ of the possible total) [144]; and the percentage of patients that ended the whole physical activity programme [145]. In addition, adherence to physical activity interventions is assessed by various types of self-reports by objective attendance records, by means of electronic monitoring devices or combinations of these, thus adding even more variability. Such variability in measuring methods reduces comparability between studies, and the

complexity introduces the possibility of boosting adherence rates in reports, thus reducing the reliability of the study. Pertinent to the present discussion is also that the statistical handling of missing data influences the presented adherence rates [146]. The adherence rates of completers exclusively conceal valuable information and covers limitations of an intervention's feasibility (unless reported concurrently).

Strongly associated with adherence to physical activity interventions are barriers to physical activity. In a literature summary of the determinants of physical activity participation, confidence in the ability to stay physically active (physical activity self-efficacy) was found to be the most frequently reported correlate of physical activity behaviour, except for demographical and biological factors [95]. The most common barriers to physical activity were lack of time, exhaustion (tiredness) or fatigue, weakness, fear of falling, bad weather, lack of training facilities and lack of training partners in addition to ill health and poor consciousness of self-appearance. In the same summary, previous exercise habits were another predictor of physical activity, as was having social support from family or friends. The importance of having a pleasant and facilitated and easily accessible environment was often reported [95] and was discussed in more detail in a recent review of qualitative evidence on the subject [147].

Implications for social equity in physical activity research

The methodological challenges outlined have clear implications for social inequity in physical activity research, of which three main points are considered. First, a research practice where the high socioeconomic group sets the premises for what physical activity is and how it should be interpreted may violate principles of validity. For the purpose of studying physical activity scientifically, physical activity is defined and operationalised by scientists; however (in parallel with Bourdieu's theory of social practice briefly recounted), researchers tend to originate from families with similar sociocultural backgrounds, and they have also been socialised into an academic culture affected by its distinctive norms and terminologies. Thus, health researchers are likely to have a shared perception of physical activity. Academics who are considered to belong to a high-socioeconomic group have the privilege of defining and operationalising a construct on behalf of all socioeconomic groups without necessarily assuring that their conceptual understanding of the construct represents them all. Although Nigg et al.

referred to ethnocentrism in their discussion of flexible questionnaires, the case outlined fits well with their advice about ensuring that both researchers and respondents understand the physical activity questionnaire currently in use for it to accurately measure physical activity [118].

Although studies have shown that high socioeconomic groups have higher levels of leisure-time physical activity [148-151], other studies showed that groups with lower socioeconomic status may be more active within the domain of occupational physical activity [152,153]. Moreover, an Australian study showed that low-income adults were significantly more likely to prefer activities at lower expenses, team-based sports and activities that were not just about exercise. Vigorous or outdoor activities were also less preferred in the low-income group [154]. Another qualitative study reported that among women with a high socioeconomic status, there was a wider variety of physical activities compared to women with a lower socioeconomic status and that women in the latter group were more likely to perform more spontaneous activities, such as walking or bicycling [155]. Hence, the perceptions of physical activity in high socioeconomic groups, including researchers, will likely not coincide with the preferences of types of physical activity of other socioeconomic groups. A biased and iterative focus on leisure-time physical activity (including exercise) as a proxy for total physical activity would therefore lead to consolidations of misrepresentations of physical activity among low socioeconomic groups, given that their physical activity is primarily performed within other physical activity domains. Nevertheless, physical activity guidelines and health policies are based on researchers' premises for physical activity. The paradox that the contemporary health discourse and well-intentioned public health interventions in general are met with approval to a lesser degree among individuals with a lower socioeconomic status compared to higher socioeconomic groups [14,84,156] and that physical activity interventions targeting low socioeconomic groups have limited effects [15,16] likely reflect a detrimental effect of researchers' definitions of physical activity and the recurrent use of questionnaires.

Resuming the discussion of construct validity, to achieve high construct validity, the basic definition of physical activity and the operationalisation of physical activity must coincide. If most studies in the field of physical activity research have operationalised physical activity as leisure-time physical activity (or: as physical exercise) at the expense of other physical activity domains, their results yield limited and inaccurate knowledge about

total physical activity. In fact, a considerable proportion of the total physical activity included within the remaining physical activity domains is excluded from the calculations. In this case, studies of the relationship between physical activity and socioeconomic status are based on false premises, and the real differences in total physical activity between socioeconomic groups remain unknown. Moreover, if the physical activity domain that is most often studied represents higher socioeconomic groups to a larger degree than lower socioeconomic groups and the omitted domains relate to lower socioeconomic groups, studies of physical activity serve the interest of, and may be more beneficial to, higher than lower socioeconomic groups. Furthermore, the more frequently such biased studies are conducted and published, the stronger is the biased 'evidence'.

Second, because of the rather narrow focus on the levels of leisure-time physical activity in questionnaire-based studies of physical activity, other factors that may be vital to physical activity behaviours in low socioeconomic groups are not assessed. For example, because questionnaires in health-related research often include response options that poorly accommodate health conditions that may hinder people from undertaking regular physical activity, the physical activity levels among people with irregular physical activity might be misrepresented. As individuals with a lower socioeconomic status are more likely than the high-socioeconomic status group to have health issues, real levels of physical activity may be misinterpreted due to the irregularity of activity in this group. In addition, if people from different socioeconomic groups have different experiences, preferences, constraints and possibilities or routines for physical activity, these aspects will not be reflected in traditional physical activity questionnaires assessing leisure-time physical activity levels only. Hence, applying traditional questionnaires in studies attempting to understand physical activity across socioeconomic groups introduces a risk of misrepresenting low socioeconomic groups.

Third, randomised physical activity trial interventions mainly include leisure-time physical activity often designed with a detailed exercise protocol. Thus, with reference to the above arguments, social equity may be a challenge to such trials. More specifically, both intervention adherence rates, and study participation as such, may be affected.

In general, studies have shown that adherence to medical treatment was previously weakly associated with socio-demographic variables [137]; however, according to the WHO, socioeconomic status as a patient-related

factor is one cause of adherence to medication in general [157] in addition to physician-related factors and health system-related factors [158]. Adherence to medically prescribed *physical activity* across socioeconomic groups seems scarcely investigated, likely due to it being a secondary aim of health-related trials and their succeeding adherence analyses, although some evidence exists. A Mexican study of women's adherence to a weight management programme, including physical activity, showed that the number of physical activity sessions attended correlated positively with income and years of education [159]. Similarly, a Canadian study of adherence to obesity reduction programmes reported a significant association between education level and non-completion, with almost two-thirds of the participants with less than a postsecondary education versus 16% of those with a university education not completing the programme [160]. In addition to the fact that outcome data become incomplete, and erroneous conclusions may be reached as a result, the conclusions might be less socially valid in cases where the attrition rates are related to socioeconomic status. In other words, the results from these RCTs apply to low socioeconomic groups to a lesser degree than to high socioeconomic groups.

In addition, despite the Consolidated Standards of Reporting Trials' (CONSORT) statement that was developed to improve the quality of RCT reports [161] as well as the Belmont report that emphasises the importance of scrutinising research samples with respect to selection biases [162][1], there is a tendency for clinical trials to lack important reports on the demographic attributes of participants, such as socio-economic status [163,164]. Such insufficiency impedes assessments of satisfactory representativeness [164], outcome biases and adherence across social groups; however, low participation rates in RCTs have been associated with narrow inclusion criteria hindered by socioeconomic status [165], often in terms of financial barriers [166,167]. Not only will the results be less valid for the population in general, although the evidence for suggesting that those who participate in RCTs have better health outcomes is disputed [168], a social inclusion bias will also conceivably deny excluded patients the state-of-the-art treatment and the benefits of services accompanying study participation [169]. Moreover, applying results from a study with poor external validity will be difficult as the total population of patients represents all social groups.

[1] The Belmont Report summarises the ethical principles identified by the National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research.

The Declaration of Helsinki [170] clearly prevents researchers from compelling vulnerable individuals to participate in research simply for the sake of obtaining representative samples, unless it is to the participants' own interest and benefit. Although these requirements are legitimate, and necessary, much physical activity research may be at risk of drawing conclusions that are invalid for vulnerable groups because they are excluded from studies.

The breast cancer case

Breast cancer is the most common cancer in women and is detected in 1.7 million women globally [171] each year. In 2019, 3.726 women in Norway were diagnosed, while 51.190 were living with breast cancer diagnosis [172]. In high-income countries, the estimated survival rates range from 72% to >90%, depending on breast cancer stage at the time of diagnosis. In contrast, the proportion is close to 50% in parts of India and Africa [173].

Briefly, breast cancer is described as an uncontrolled growth of breast cells, usually lobules cells (milk ducts), causing a malignant tumour in the breast. The breast cancer diagnosis covers many different classifications of breast cancer diagnoses, including five stages of cancer (0-IV) determined by tumour size [174]. Breast cancer at stage 0 describes cancers that remain within the lobules in which they started (non-invasive), whereas stage IV includes invasive cancers that have spread and grown into healthy tissues beyond the breast (advanced, or metastatic) [175].

The complexity of breast cancer diagnoses requires a wide spectre of different treatments, such as surgery, radiation treatment, chemotherapy, targeted drugs and/or immunotherapy drugs. Different plans of treatment depend on the type, stage, tumour location, the patient's age and health condition and the chance that a specific treatment will affect the cancer. Breast cancer treatments contribute to the burden of short- and long-term side effects experienced by many survivors. According to the American Cancer Society [176], typical side effects of chemotherapy (drugs given intravenously or as fluid or pills in tailored intervals) are nausea, fatigue and hair loss. Possible consequences of targeted therapy, i.e. drugs acting on the changes within the cancer cells, are skin changes (e.g. rashes) and increased blood pressure. Some of these side effects also occur with the use of immunotherapy (drugs given intravenously to support the body's immune

system in fighting the cancer). The type and extent of breast surgery (i.e. simple, total, modified radical or radical mastectomy and breast preserving conserving or reconstruction) may have psychological and physiological outcomes. Radiation and brachytherapy (high-energy rays used to kill cancer cells) may be used alone or in a combination with surgery or chemotherapy and may cause fatigue and skin changes in some patients. Long-term breast cancer survivors may experience long-term effects from treatment, such as fatigue, premature menopause, weight gain and cardiac dysfunction. Nonetheless, there are reasons to assume that both short- and long-term effects affect breast cancer survivors' motivation in relation to physical activity.

Breast cancer survivors

Any woman with an individual breast cancer history may be referred to as a breast cancer survivor[2]. Statistical reports often refer to five-year survival rates to describe the percentage of individuals who live at least five years after they were diagnosed [175], and hence many studies define breast cancer survivors as women who are alive five years post-diagnosis. Other studies define survivors as individuals who have completed primary cancer treatment [177]; however, due to wide varieties in the cancer trajectory, i.e. varying endpoints of primary treatment, and because the number of years are of little use in predicting individual chances of surviving, the concept of different survivorship *stages* [178] appears more applicable. Within this conceptual frame, the *acute stage* is the time from diagnosis through the end of treatment when the focus is on the actual disease, whereas the *extended stage* begins when and if the patient responds to treatment when patients and caregivers may feel positive yet uncertain and a fear of recurrence is often present. The *permanent stage of survivorship* refers to the long-term stage of survival when a level of confidence for health and life returns to the person affected by cancer and recovery is celebrated [178].

[2] <1% of all breast cancers incidents are male breast cancer. These cases are not discussed in the present thesis.

Distribution and physical activity by socioeconomic status in breast cancer survivors

The impact of socioeconomic status on breast cancer incidence rates, survival and health-related quality of life after treatment is increasingly recognised in epidemiological studies. From a social health inequality perspective, the breast cancer diagnosis is of interest because the mortality figures across socioeconomic groups are much like they are for other diseases, despite the fact that the incidence rates are higher for women with a higher education level [21,179]. A comprehensive review of socioeconomic inequalities in breast cancer incidence and mortality in Europe [180] reported significantly positive associations between education and breast cancer incidence in Nordic [181-184] and French studies [185]. These findings are similar to results reported from other Western countries, such as from the US [186] and Norway [187,188]. According to Trewin et al. [20], the incidence rates in Norway were significantly higher in women with higher education compared to women with lower education throughout 1971–2009. According to a meta-study of Lundquist et al., reproductive factors (age at first birth, parity, age at menarche), mammography screening, hormone replacement therapy and lifestyle may be explanatory factors of the significant socioeconomic differences in breast cancer incidence [180].

Although there is evidence of a positive association between higher education and breast cancer incidence [180], higher education has been associated with higher survival rates [21] and better self-reported health-related quality of life [179]. In Norway, women at the highest educational level aged >35 years had a 38% higher risk of being diagnosed with breast cancer than women in the lowest educational group from 2000–2009, whereas the risk of dying from breast cancer was 28% greater among the lowest compared to the highest educated women in the 35-49 years age group during the same period. Although overall mortality rates decreased during this period and the mortality rates of higher educated women remained stable from 1970–1990 [189], the mortality rates decreased faster in groups of high-educated women compared to groups of low-educated women in the years after 1990 [20]. Although racial differences in breast cancer have not been as pertinent in Norway as in, for example, the US, a recent study indicated that groups of immigrants (Pakistani, Sri Lankans and Somalians) living in Norway have significantly worse outcomes after being diagnosed with breast cancer compared to ethnic Norwegian women [190]. For some immigrant groups,

this may be partly due to lower attendance rates of mammographic screening [191].

The association between socioeconomic status and mortality and fatality rates have been thoroughly discussed. Because there is evidence of delays in consulting a physician [192] and less use of adjuvant endocrine therapy among women with a lower socioeconomic status [193,194], patient delays, which are related to more advanced breast cancer tumours [195], have been an assumed decisive factor. These suggestions are supported by findings in the review of Lundquist et al. [180]. In some countries, poor access to health services and health education can lead to social inequalities in breast cancer. Moreover, as previously mentioned, taking advantage of mammography screening seems to be socially patterned, which detects breast cancer at an early stage and is therefore possibly easier to cure [191,196]; however, according to Lundquist et al.'s summary [180], an unhealthy lifestyle, including high levels of physical inactivity, may be as important as belated examination. Nevertheless, it is not clear whether the social inequalities in survival rates are actually affected by social inequalities in physical activity. Regardless, there are reasons to be aware of possible social differences when physical activity is implemented as part of breast cancer treatment and rehabilitation.

Breast cancer and physical activity across socioeconomic status

Based on the evidence of the impact of physical activity on health and the fact that breast cancer is one of the most common causes of mortality in women [197], there has been an increased interest in research on risk reduction, effects and levels of physical activity throughout the breast cancer trajectory. The relationship between physical activity and the risk of breast cancer surfaced in a number of cohort- [198-202] and case-control studies [203-208] in the 1990s. In 2007, a systematic review, including an additional 37 studies, showed that the associations were evident for leisure-time physical activity in postmenopausal breast cancer (risk reductions of 20-80%) but less significant for premenopausal breast cancer [209]. These findings were reproduced in another review in 2011 [210]. Admittedly, the review of Monninkhof et al. [209] did not include articles that reported on occupational physical activity exclusively. In addition, the review reported that studies that included occupational physical activity in the analyses showed that the risk of breast cancer had a smaller decline. A recent meta-

analysis of 45 cohort study reports supported findings from preceding reviews, adding that the overall relative risk was reduced for occupational physical activity as well [211]. Almost concurrently with the first wave of studies of physical activity and breast cancer risk, the effect of physical activity on cancer survivors' quality of life was observed. An early review of 24 studies (mostly experimental or quasi-experimental, and 14 breast cancer studies) with some reservations with regard to sample sizes and designs indicated that physical exercise after being diagnosed with cancer had positive effects on several elements of cancer survivors' quality of life [212-215]. Moreover, previous studies support that physical activity may improve physical fitness [212,213,216,217], physical functioning [212,214,218] and fatigue [212-214,219] in breast cancer patients. Recommendations of physical activity in breast cancer survivors are related to the fact that being overweight and obesity are poor diagnostic factors and are associated with several undesirable outcomes [220-222]. Together with the problem that many breast cancer survivors report weight gain [223,224], regular physical activity to maintain a desirable weight is considered one of the most important lifestyle pursuits [225]. Regarding the risk of recurrence and breast cancer-related death, it was concluded in a review of de Boer et al. that there is strong evidence that these factors are strongly associated with physical activity due to the biologic mechanisms affected, assumedly leisure-time physical activity only [226].

Compared to healthy women, breast cancer survivors engage in recommended physical activity on the same level [227-229]. Barriers to physical activity among breast cancer survivors are reported to be perceived lack of knowledge of or enjoyment from physical activity, decreased body image or dispiritedness [230] and a time squeeze or lack of company [231-233]. These are, of course, barriers much alike barriers experienced in the general population [231]. Fatigue, neuropathy and joint pain are more cancer-specific physical activity constraints [231,234]. A qualitative study added situational barriers (distance to training premises, or heavy traffic) and institutional barriers (competing roles and time scheduling) to the set of physical activity barriers identified among breast cancer survivors [235].

Previous studies indicate that similar to the population in general, there are differences in physical activity among breast cancer survivors across socioeconomic status groups. Based on questionnaires assessing walking and exercises levels, highly educated breast cancer survivors were found to be more physically active than survivors with less education [236,237]. This

trend is supported by a questionnaire-based study of recreational physical activity, reporting that public physical activity recommendations of 150 min/week in moderate-to-vigorous physical activity are less likely to be met by breast cancer survivors residing in low-socioeconomic status neighbourhoods [238]. A study based on accelerometer data also showed lower levels of physical activity in breast cancer survivors without university degrees compared to their high-socioeconomic status counterparts [239]. Little is known about social differences in barriers to physical activity among breast cancer survivors across socioeconomic groups; however, an African study indicated that women with low education to a higher degree felt discouraged, had a fear of injury, a lack of company and equipment, facilities or space and knowledge of how to exercise, good health and energy than more educated women [233]. A qualitative study of perspectives of breast cancer survivors from diverse racial and socioeconomic backgrounds towards physical activity showed no differences in beliefs regarding the importance of physical activity [240]; however, weather was a larger barrier among non-Hispanic whites compared to African Americans, and clear differences in the community environment as a perceived facilitator for physical activity were found for non-Hispanic Whites, mentioning it twice as much as African American survivors. Moreover, the non-disadvantaged group of breast cancer survivors mentioned the community environment as a facilitator for physical activity three times more often than the disadvantaged group. Most studies on socioeconomic differences in the amount of physical activity among breast cancer survivors are conducted by means of questionnaires assessing leisure-time physical activity, and thus the evidence of socioeconomic differences in total physical activity levels in this group is not clear.

Research participation and adherence to physical activity among breast cancer survivors

Many physical activity intervention studies have been conducted in the population of breast cancer survivors. In these cases, it has been reported that having too many things on one's mind, wanting to exercise on one's own, timing problems, the amount of time investment, not wanting to exercise, travel distance and not wanting to participate in a RCT were the main reasons for not wanting to participate in a physical activity intervention, independent of socioeconomic status [241]. In a review of reported barriers to clinical trial participation for cancer patients in general, older age, low socioeconomic status and ethnic / racial minority status were barriers associated with the

opportunity to participate [242]. In the case of socioeconomic differences in physical activity trials, associations between adherence rates and socioeconomic groups have been reported: In a Dutch [143] and an American [243] study of breast cancer patients, a higher educational level predicted a higher adherence to exercise-based interventions. Furthermore, employment was associated with better intensity adherence in a Taiwan walking exercise intervention study of breast cancer survivors [244]. Nevertheless, socioeconomic differences between intervention completers and withdrawals in these patient groups have also been found to be non-existent [245,246], or dropouts have been found to be more likely to be unemployed or to have lower education than completers [247]. Notably, all these trials included a leisure-time physical activity intervention.

The consequences of participation and adherence variations in physical activity trials were contextualised in the guidelines of exercise for cancer survivors developed by the International Multidisciplinary Roundtable in 2019 [248]. These guidelines emphasise that evidence on the safety and efficacy of exercise in cancer survivors were derived from RCTs, and *'hence, the individuals enrolled in studies commonly meet prespecified eligibility criteria (…) and were willing to participate in research. This often results in a sample that is healthier or with higher physical function and exercise motivation that may not fully generalize to the broader population of cancer survivors'* [248] (p.2384). This quote reflects a certain consciousness of external validity in these studies, and it also indicates that breast cancer studies involving physical activity are relevant cases in studying the social consequences of methodological practice in physical activity research, albeit physical activity research on other diagnostic groups might well reflect similar patterns.

Summing up

An important aim of Norwegian health policies is to reduce social inequalities in health [22,23,249,250]. In this context, it is important to be aware of the different physical activity behaviours of different socioeconomic groups. As demonstrated, physical activity has evidential health effects, and there has been ample research activity within the field of physical activity in the treatment and rehabilitation of breast cancer survivors. Because physical activity is an intricate phenomenon, studying

physical activity in vulnerable groups may complicate accurate conclusions. To reduce the risk of further widening inequalities in health in general, and in breast cancer survival in particular, accurate measures in all phases after breast cancer diagnosis depend on detailed, valid and reliable knowledge of different physical activity behaviours within groups of breast cancer survivors. Systematic research on socioeconomic disparities in studies of physical activity in women affected by breast cancer can assist in reducing the likelihood that the observed social health inequalities in this group increases and can help to ensure that treatment and rehabilitation services, including physical activity, are available and relevant for all breast cancer survivors.

3. Research Questions

In the context of social inequalities in physical activity, the starting point for the papers included in the present thesis was the systematic review of studies on socioeconomic differences in physical activity among adolescents, which was previously published by the present author [17]. The inconsistent associations reported in studies of the adolescent population, and the prompt peer-reminder of a generally narrow perception of the concepts of physical activity and exercise [18], gave rise to a second, yet different, systematic review. Taking the limitations in the first review into consideration, we recognised that there was a need for an overall clarification as to whether the entire domain of physical activity research had made the same mistake and thus whether physical activity researchers had failed in their interpretations of how socioeconomic status relates to physical activity. The first research aim was therefore:

…to identify variations in findings across individual studies examining the relationship between socioeconomic status and physical activity and to examine whether these findings might be linked to which physical activity domains have been investigated.

As the results reported in the first paper supported our hypothesis that the association between socioeconomic status and physical activity holds only for some physical activity domains and because most research within the field of physical activity research has focused on leisure-time physical activity only, the first paper gave rise to a concern about the knowledge basis for physical activity measures, such as interventions or rehabilitation programmes targeting vulnerable individuals who are possibly less active during leisure time. Due to the volume of physical activity research within the field of breast cancer and the evidential gradient of social inequality in survival rates, the breast cancer population was introduced as a case. A central question was whether the instruments commonly used in measuring physical activity in breast cancer populations were assessing leisure-time physical activity only and thereby were underestimating the total levels of physical activity, thus masking other aspects of physical activity that might be significant in the rehabilitation of, or interventions for, breast cancer survivors in low socioeconomic groups. Thus, the aim of the second paper was:

…to identify levels of daily routines for and experiences with physical activity among long-term breast cancer survivors in general and on the part

of socioeconomic groups and to explore whether a mixed-method approach might unveil diversities of physical activity practice in breast cancer survivors across socioeconomic groups.

From the two preceding papers, a second concern emerged regarding the group of low- socioeconomic breast cancer survivors' possibility to participate and their ability to complete physical activity trial interventions that are set up to study the effect of exercise on health outcomes relevant to breast cancer. Considering external validity, the aim of the third paper was therefore:

… to investigate overall and quarterly adherence to an outdoor 12-month post-surgery supervised exercise intervention among breast cancer patients receiving adjuvant treatment and to identify possible predictors of adherence, such as sociodemographic and health variables.

4. Methodology, Methods and Material

The present overall project explores social inequalities in physical activity and evaluates the methods utilised within the context of physical activity research, thus fitting well with the description of a case study. According to Yin [251], a case study can be defined as *'an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident',* which is used in a variety of disciplines [252], including healthcare (see for example [253]). As a case study is often applied in evaluation research to describe and to explore a phenomenon within the everyday context and to explain presumed causal links that cannot be explained by other methodological approaches, the present thesis seeks to explain possible connections between common methodological solutions in physical activity research and the knowledge of social inequalities in physical activity produced by such research. Collecting data for the purpose of evaluating research by means of questionnaires or in-depth interviews with health and physical activity researchers themselves would likely yield unreliable data as the respondents would not likely be fully impartial or objective in their answers about their own research. Therefore, a case-study approach that allows for other sources of evidence and types of knowledge and enables a multisided and socially representative image of the topic would be suitable for answering the overall question.

Part I: Building theory from hidden patterns

As opposed to a single study including original data, a systematic article analysis of previously published scientific studies enables researchers to summarise paradigm- or domain-specific knowledge [254], which in the present case was the prevailing knowledge of the association between physical activity and socioeconomic status as well as of established conceptual operationalisations of physical activity dominating the sub-paradigm of physical activity research. In addition, an analysis of explicit knowledge content allows for further discoveries of hitherto hidden patterns [255] of, for example, an imbalanced relationship between socioeconomic status and different physical activity domains. Adopting the epistemological model of Schryen and Wagner [256], Paper I thereby contributes to knowledge conversion not merely by synthesised presentations of the literature. Rather, by studying published literature from new perspectives, we

gain more nuanced insight into the relationship between the variables of interest and possibly reveal knowledge gaps within the research field as a result. By identifying variations in findings across individual studies examining the relationship between socioeconomic status and physical activity, and possibly proving that these findings are linked to which physical activity domains have been investigated, a theoretical basis for further investigation may be laid as a consequence.

Part II: Bringing previously unnoticed aspects of physical activity differences to the surface

As argued in a previous section, using proper measuring methods is decisive in depicting people's physical activity practices reliably, and using physical activity questionnaires may have substantial information shortcomings with respect to socioeconomic inequalities. With reference to Tashakkori and Teddlie [257], a mixed-methods approach including different methods of collecting physical activity data enables dataset comparisons both individually and crosswise to confirm, complement or possibly contradict results across socioeconomic status. From these results, possible socioeconomic distinctions in physical activity practices could be revealed, which otherwise might have been concealed in traditional datasets.

Part III: Detecting social patterns of physical activity intervention participation

In intervention studies including demanding physical activities, the study's data quality highly depends on participation stability throughout the intervention period [130]. Attendance data from patients participating in a physical activity clinical intervention study could enable an analysis of the associations between socioeconomic status and adherence to the physical activity intervention programme as well as an evaluation of whether a physical activity intervention is suitable for all socioeconomic groups.

Table 1: Project overview, including aims, methods, and approaches for SES-PA-related analyses in each part of the thesis

	Aim a)	Aim b)
Overall	**To identify social inequality in different aspects of PA**	**To examine whether methodological decisions in PA research affect reported PA behaviours differently between SES groups**
Design & methods	**Case study**	
	A variety of methods & analyses	***A variety of methods & analyses***
I	to identify findings across studies examining the relationship between SES and PA	to examine whether differences in PA between SES groups might be linked to which PA domains have been investigated
Design & analyses	Systematic article analysis	
	Frequencies of positive, negative or mixed SES-PA associations in published studies	*The proportion of studies reporting each type of association for different PA domains*
II	to identify levels of daily routines for and experiences with PA among long-term BCS in general and on the part of SES	to explore whether a mixed-method approach might unveil diversities of PA practice in BCS across SES
Design & analyses	Cross-sectional mixed-methods study	
	Mean rank comparisons of levels, descriptive comparisons of routines and qualitative descriptions by SES group	*Contradictions and complements or confirmations of differences in PA behaviour across methods*
III*	…and to identify possible predictors of such adherence, such as sociodemographic and health variables	to compare (inclusion), full sample and dropout characteristics
Design & analyses	Cross-sectional 'feasibility' study	
	Correlations of adherence and SES, mean rank group comparisons of group- and at-home PA adherence	*Comparisons of full sample and dropout characteristics and reasons for not participating*

PA=Physical activity, SES=socioeconomic status, BCS=Breast cancer survivors
*The study aims are turned the other way around to correspond to the order of the thesis' overarching purposes

Study designs and subjects of study

Usually, a case study approach makes use of multiple sources of evidence, including both qualitative and quantitative data [252], of which documents are considered to be particularly relevant [251]. Therefore, an introductory systematic article analysis of scientific publications (Paper I) was followed by two cross-sectional studies based on data from one retrospective study (Paper II) and one randomised controlled trial (Paper III), respectively. While the first paper examined the final part of the knowledge production chain (i.e. the published results), Papers II and III focussed on other elements of the research process, from one study each.

All three papers have the same twofold focus, which reflects a) a traditional analysis of the association between socioeconomic status and physical activity and b) a meta-perspective considering the consequences of a methodological research practice in the measurement of physical activity across socioeconomic groups. Table 1 provides the overall design showing the twofold aim, the variations between Papers I–III and the analytic approaches, respectively.

The first question regarding socioeconomic differences in physical activity was dealt with by identifying results across published individual studies that have examined the relationship between socioeconomic status and physical activity (Paper I) by identifying socioeconomic differences in the levels of daily routines for and experiences from physical activity in a cross-sectional study of permanent breast cancer survivors (Paper II) and by investigating whether socioeconomic status might be a predictor of adherence to a physical activity intervention among acute breast cancer survivors (Paper III). The second question regarding the consequences of a methodological research practice was answered by examining whether associations between socioeconomic status and physical activity are linked to the domain of physical activity studied (Paper I) by exploring whether new aspects of the social diversity in physical activity relevant to low-socioeconomic status groups would emerge from alternative methods (Paper II) and by comparing full sample and dropout characteristics (Paper III).

Data sources

In total, five datasets from three different studies have been analysed for the purposes of the present thesis. The first paper included a set of 56 previously

published scientific, peer-reviewed articles retrieved from systematic searches in three databases of relevance to health sciences. The MEDLINE database indexes a wide spectre of journals within the health sciences, such as medicine, preclinical sciences, odontology, nursing and veterinary medicine [258]. Web of Science is described as one of the best-known international databases for academic research, including references to leading journals in science, social science and humanities [259] whereas SPORTDiscus is the leading source of literature in sports and sports medicine studies, providing extensive coverage in studies of fitness, health and sports [260]. The specific search strategies are described in detail in the published article.

Paper II involved three different datasets collected from a total of 52 participants from 'The Radiation Study', which is a longitudinal follow-up study of health-related quality of life and late-effects after radiation therapy and includes Norwegian breast cancer survivors who were diagnosed from 2007–2008 (*n*=250). A detailed description of the main study's recruitment procedure can be found elsewhere [261]; however, participants in our sub-study (Paper II) were recruited at the main study's 7–8 year follow-up check at the outpatient clinic. The following sets of data were collected: all participants completed a *follow-up questionnaire for the main study* (*n*=71) and were subsequently invited to the sub-study to give an *interview* (n=37) or to write an *activity-log* (*n*=52) or both. A total of 31 women provided information for both interviews and activity-logs in addition to questionnaires.

In Paper III, the data were derived from a larger randomised controlled physical activity trial in breast cancer patients (the Energy Balance and Breast Cancer Aspects II - study) [262]. Women who were living in Norway and diagnosed with breast cancer were initially included in the trial between 2012 and 2017 at the Cancer Centre, Oslo University Hospital, St. Olav Hospital, Trondheim, and Vestre Viken HF, Drammen. Patients were randomised to either the intervention or the control group 8–12 days after surgery. The data used in paper III were based on baseline pre-surgery information from *questionnaires and tests* in addition to *exercise participation records* and *structured logs* from at-home physical activity. All data points were merged into one file, from which data from the 47 patients who were randomised to the intervention group run by St. Olav Hospital, Trondheim, were analysed.

Subjects and units of study

Paper I included scientific documents as its study objects represented by peer-reviewed research articles published in scientific journals between 2000 and 2014. Although no human subjects were included in the study, an inclusion criterion was that articles had to report empirical studies with original data, including data from national surveys, that represented adult participants (>18 years) of both genders (total N=207,156). Articles were excluded if they reported studies of a patient group exclusively, and thus neither breast cancer survivors nor any other patient group was considered. All inclusion and exclusion criteria are accounted for in the article.

In Papers II and III, all participants, who were all women, are referred to as breast cancer survivors; however, they had different breast cancer trajectories in terms of the treatment and how long it was since they were diagnosed with breast cancer[3]. According to Mullan's definition of phases of survivorship described previously [178], the participants in Paper II (N=52) are considered permanent survivors as they were included in our sub-study 7–9 years after radiation therapy. The mean age was 62 and 61 in the logbook/survey and interview sample, respectively. Most women were paired (81 and 65%, respectively), and 23% of the women in the logbook sample had a college degree or more, whereas 22% of those in the interview sample held such educational level. In Paper III (N=47), the participants were in the acute stage of survivorship [178] as they were included shortly after diagnosis. At the baseline, the mean age of the intervention group participants was 54, and 83% of the women lived in the hospital municipality, 96% had Norwegian parents and 70% were married/had a partner. Moreover, 55% of the women in the total sample for Paper III held a college degree or more, and 79% had been working the previous 12 months. Further inclusion and exclusion criteria defining the samples are described in the papers.

[3] The continuous improvements in breast cancer treatment imply that the late effects experienced by long-term survivors diagnosed in 2007/2008 (Paper II) may be less explicit in breast cancer survivors diagnosed between 2012 and 2017 (Paper III).

Assessments of key variables

Physical activity

As described, physical activity is complex, including the variety in its constituents (type, intensity, duration and frequency), the distinctions of its domains (leisure-time, housing, transport and occupational physical activity) and the psychosocial aspects of individual's anticipations and habits and personal experiences with physical activity. In line with a case study approach [251], different elements of physical activity have been studied throughout Papers I–III to investigate socioeconomic differences and possibly socially biased research mechanisms. The different aspects of physical activity (and indicators of socioeconomic status) are shown in Table 2.

Table 2 Indicators of socioeconomic status (SES) and aspects of physical activity (PA) assessed across Papers I-III

Paper	SES	Physical activity (PA)
I	Education Income Occupation Neighbourhood Other	Levels of PA Article inclusion criteria was that PA had to be assessed by all the following dimensions: PA type or mode, intensity, frequency and duration of PA
II	Education Household income Occupation	Levels of, routines for and experiences from PA assessed by means of questionnaires, 7-day PA logs and interviews, respectively
III	Education Household income Occupation	PA adherence to group exercise sessions and at-home PA based on attendance reports and self-reported PA logs, respectively

Inspired by Warren et al. [97] and Rice and Howell [102], among others, we measured all physical activity dimensions (type, intensity, duration and frequency) where appropriate. In Paper I, this goal was dealt with by the inclusion criterion. To be included in the dataset, an article had to report a study that used an instrument that assessed all four dimensions; however, there were no such criteria of which dimensions were in fact reported in the studies.

In Paper II, we compared and combined assessments of different aspects of physical activity by means of the traditional questionnaire with other alternative instruments. The level of physical activity was assessed by means of questionnaire and activity logs, from which we registered the types from a predefined list and from the participants' own log registrations,

respectively. Frequency was assessed by ticking boxes of the number of activity bouts per week in the questionnaire and by counting the activity bouts that were noted in the activity logs. The intensity dimension was also registered from predefined alternatives in the questionnaire, whereas in the logs, we registered the lowest intensity ('no sweat or heavy breath') unless the respondents had reported differently (i.e. higher intensity). The traditional (questionnaire) and the alternative (logs) assessment instruments compared, the measures of activity duration were probably the most different as it was measured by ticking-boxes with predefined alternatives in the questionnaire compared to number of minutes from activity start to activity ending, as noted, in the logs. Other measures of physical activity that were relevant to the aspect of physical activity habits (routines) were the time of day of physical activity (divided into four periods during 24 hours); company while in physical activity; where the physical activity took place; and the activities before and after physical activity (e.g. watch TV, eating, doing errands).

The physical activity protocol for the intervention reported in Paper III instructed (group) exercise for 2x60 min/week, and compliance to required exercise intensity was accepted by completing the exercise session. Adherence was referred to as a percentage of full attendance, defined as attending 80 group sessions for 12 months registered by supervising physiotherapists. In addition, participants were requested to do unsupervised physical activity of at least a moderate level for a minimum of 120 min/week at home and were asked to deliver logs of the type, duration and intensity. Based on submitted activity logs, adherence was calculated as a percentage of the required 120 min/week.

Socioeconomic status

Multiple measures of social position exists, including different interpretations of social class and social or socioeconomic status [53]. It is agreed that the conceptual choice should be theoretically founded and made in light of the research question and the units of analysis [52]. Here, socioeconomic status is the generic indicator for social position; however, it was differently composed of mostly individual-level indicators throughout the three papers (I–III).

In Paper I, we registered all measures of socioeconomic status that were used in each included article. Two to five measures of socioeconomic status were

used for each study; education and occupation were used in 86 and 25% of the included articles, respectively. Other measures were income, neighbourhood (postal code or area) and other (i.e. employment status, number of children, access to motor vehicles, marital status, subjective definitions of socioeconomic status, settlement, housing tenure, household, assets, free lunch, job duration, work status, number of cars or level of deprivation).

As also learned from Paper I, the most often used indicator of socioeconomic status in health-related research is education. This indicator captures knowledge-related resources, which are thought to influence an individual's ability to accommodate a healthy behaviour [53], such as physical activity. Education was assessed by means of a questionnaire as level of education in Papers II and III as well as the continuous variable of total years of education in Paper III.

Due to historical reformations in the Norwegian school structure (among other issues, the right to 12-year school was introduced after the eldest women in our sample had finished their schooling), an intermediate category of upper secondary education, which was of less than three years, not including completion of high school, applied to many women in the study that is reported in Paper II. To distinguish between the intermediate level and contemporary upper secondary education (which is equivalent to the final high school level), we named these categories as 'Upper secondary, basic (<12 years)' and 'Upper secondary, final (12 or 13 years)', respectively, in accordance with the Norwegian Standard Classification of Education, Statistics Norway.

In physical activity research, the income variable has been considered relevant for social inequality due to, for example, sport equipment costs and membership fees. In both Paper II and Paper III, predefined household income groups were given in the questionnaire as predefined ticking-boxes as follows: <100.000; 100.000–299.999; 300.000–499.999; 500.000–699.999; 700.000–899.999, and ≥900.000 (Paper II), and ≤349 999; 350.000–599 999; 600.000–999.999 and ≥1.000.000 (Paper III).

The occupation indicator of socioeconomic status is widely used, mostly due to its correlation with education. In Paper II, occupation was assessed from the interviews and classified using the Statistical Classification and Code list from Statistics Norway [263]. In Paper III, occupation class was assessed using a version of the occupational classification in the HUNT Study [264]

and recoded into the Erikson Goldthorpe Portocarero social class scheme in accordance with Krokstad et al. [265] (unskilled; semi-skilled; skilled manual/artisan; other self-employed/farmer/fisherman; non-professional occupation; professional occupation; public/private management position; academic management position). Complete descriptions of how the socioeconomic variable was recoded are given in the three papers, respectively.

Data preparation and analyses

The variety of methods guided rather different approaches to the analyses. Data extracted from the included articles in Paper I were manually registered in Excel. Geographical clusters (i.e. world continents) and measures of socioeconomic status were used to analyse possible associations with the domains of transporting-, household-, occupational- or leisure-time physical activity. Articles were first classified by the direction of the relationship between socioeconomic status and physical activity (positive, negative or mixed associations). The results were then summarised according to the direction of the association and the physical activity domain reported.

A sequential mixed-methods approach was applied for the analyses of traditional questionnaire data and alternative activity-logs and interview data provided by the 52 women studied in Paper II. Socioeconomic and physical activity data from the main study's follow-up questionnaire were transported to SPSS for statistical analyses. A parallel mixed analysis was conducted, although full sample analyses of questionnaires and contrasting case analyses of logs and interviews were run sequentially [257] to detect differences in physical activity behaviours between socioeconomic groups. To analyse possible socioeconomic differences in physical activity in the log material and the set of interview data, we defined subsamples of the highest and the lowest socioeconomic status groups based on a combined rank of education level, income and occupation. Data from eight and nine women from the highest and the lowest socioeconomic groups, respectively, were selected for these analyses.

Log-book information about 24-hour daily-life activities was analysed using the VISUAL-TimePAcTS application, which provides summaries of places and minutes performed within each activity coded as well as various visual representations of the logs [266]. The log information was filtered to provide visual representations of physical activities only. Thus, the activity-log

depiction of all daily-life activities, including sleeping, preparing and eating meals, driving a car, etc. (depicted in Figure 1a), was reduced to a depiction of leisure-time and transport physical activities (Figure 1b and c). Finally, we added housing physical activity to visualise its impact on total physical activity (Figure 1d).

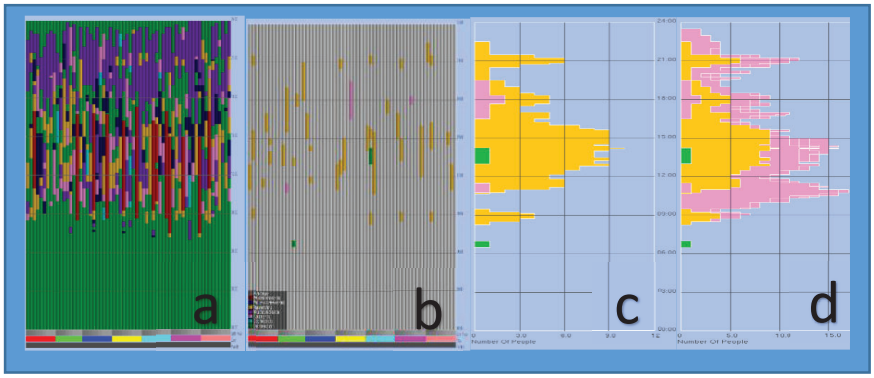

Figure 1: Examples of activity log representations through the analysis. Each vertical bar represents one 24h day logged by one person. Each activity has its own colour. The 7-colored horizontal bar in a) and b) indicates the 7-day week. a): all daily-life activities, including sleeping, preparing and eating meals, driving a car, etc., are included, b): leisure-time and transport physical activities are abstracted from the remaining, c) the sum of leisure-time and transport physical activities per domain logged at different hours throughout the week, and d) housing physical activity is included (expanded pink areas) to visualise its impact on total physical activity.

Statistics

Different statistical methods were applied in Papers II and III. All statistical analyses were performed using SPSS Statistics (v25, v26 or v27), except for calculating attendance frequency in Paper III and conducting descriptive analyses of dimensions (type, intensity, frequency and duration) and routines (places, time of day, company and daily-life activities before and after) of physical activity reported in Paper II, which were done by means of Excel.

In Paper II, Mann-Whitney U tests were run for rank differences between high- and low-income groups and between high- and low-educational groups (n=20 and n=30) regarding questionnaire-reported frequency, intensity and min/day of physical activity. Subsequently, Mann-Whitney U tests to determine rank differences between the subsample socioeconomic groups (n=8 and n=9) in physical activity bouts/week and min/day assessed in activity-logs were performed. In addition to Kruskal-Wallis' tests, non-parametric Mann-Whitney U tests were also performed in Paper III to

examine rank distribution differences in adherence to groups' exercise sessions and unsupervised at-home physical activity between groups, including groups with high and low education, high and low income and 'white'- and 'blue'-collar occupational class. To exhibit the impact of including withdrawals in adherence-rates reports in Paper III, we ran identical non-parametric analyses for the sample with (n=47) and the sample without withdrawals (n=36).

To test the relationship between socioeconomic status (and health variables) and adherence to the physical activity intervention for Paper III, the Kendall's *tau-b* and the Pearson's r correlation coefficient method for ordinal scale and nominal scale measures, respectively, were used. Sequenced Holm-Bonferroni-corrections for multiple tests were performed on significant correlations for Paper III. For Paper II, Bonferroni-corrections as a post-hoc Kruskal Wallis' test were used to detect significant differences in mean rank adherence between groups. The level of significance was set at 0.05 ($p \leq 0.05$) for both Papers II and III.

Ethical Issues

Both parent studies from which the data used in Paper II and III were selected—'The Radiation Study' and 'The EBBA-II Study'—have been approved by The Regional Committee for Medical and Health Research Ethics (REK) in Norway (case number REK 2009/108, and REK 2014/945, respectively). The participants received written information regarding how data were stored and protected, and in both parent studies, the participants signed informed consent forms. Promised confidentiality was met in 'The Radiation Study' as the participants were referred to as patient-IDs in interview transcripts and as random alphabetic letters in the published article (Paper II). In the study's baseline questionnaire and activity-log data (Paper II) as well as in all EBBA-II data (Paper III), all information from the participants was de-identified to ensure anonymity. Regarding health risks related to the exercise intervention, all EBBA-II participants were closely watched by professionally trained health personnel. In addition, they had the opportunity to contact health personnel throughout the study. In 'The Radiation Study', the participants decided where and when the interview should take place. Thus, some of the interviews were conducted in the participants' private homes, while others took place in the hospital's interview room at the radiotherapy department. The latter were considered

convenient if medical examinations in the main project coincided, although the location could remind participants of difficult experiences. Therefore, the interviewer team assured that they felt confident regarding the premises. Moreover, the women were free to refuse to answer undesirable questions. If the participants wanted to provide further information after the interview, they were welcome to call the researchers at any time.

5. Summary of Findings

Paper I

Are differences in physical activity across socioeconomic groups associated with the choice of physical activity variables to report?

The aim of Paper I was to investigate whether a generally assumed positive relationship between socioeconomic status and physical activity may have been overestimated and to identify variations in findings across individual studies to examine whether these variations could have stemmed from the selection of the physical activity domains investigated. A total of 56 studies retrieved from computerised bibliographic database searches as they applied to the dimensions of intensity, frequency, type/mode, and duration were included and examined. After dividing physical activity into four domains—transport physical activity, occupational physical activity, housing physical activity and leisure-time physical activity—the analyses showed that the positive relationship between socioeconomic status and physical activity held only for leisure-time physical activity, whereas the relationship was non-existent or even opposite for transport, occupational and housing physical activity. The sub-analysis of the 26 studies, which presented gender-specific results, revealed that the relationship between socioeconomic status and physical activity was positive for both genders in the leisure-time physical activity domain but that the relationship between socioeconomic status and occupational physical activity may be less established in women. From these findings, we concluded that the assumed positive relationship between socioeconomic status and physical activity is mainly a relationship between leisure-time physical activity and socioeconomic status, suggesting that the domain of physical activity should always be considered when studying said relationships.

Although Paper I deals with physical activity in the population in general, the result indicates a misrepresentation of individuals with lower socioeconomic status, which is a result that in turn sets the grounds for further investigations of social inequality in physical activity research within more specific populations.

Paper II

Physical activity in long-term breast cancer survivors - A mixed-methods approach

In Paper II, we aimed to identify levels of-, daily routines for-, and experiences with physical activity among long-term breast cancer survivors in general and based on socioeconomic status and explore whether a mixed-methods approach might unveil diversities of physical activity practices crucial to identifying socioeconomic differences in this group. The idea was that a triangulation of methods might cause topics, significant to breast cancer survivors with fewer resources, were brought to the surface. A total of 52 women provided data by answering questionnaires, writing activity-logs and giving interviews. A total of 31 women contributed with information to all three datasets. The results demonstrated that depending on the physical activity measure chosen, 23–63% of the total sample met the public guidelines for physical activity of 150 min in moderate physical activity per week. Furthermore, a neighbourhood walk was the most preferred type of physical activity reported, while scheduled exercise was a rare activity. Regarding socioeconomic status differences, a larger proportion of breast cancer survivors with high socioeconomic status was categorised as physically active compared with breast cancer survivors with low socioeconomic status. Moreover, according to the activity logs, the high-socioeconomic status group performed a significantly higher number of physical activity bouts for one week than the low-socioeconomic status group, although there was no significant difference in total duration of physical activity between the groups. For all participants, physical activity was perceived as medicative, but, particularly in the low socioeconomic group, physical activity was normatively described and accompanied by unfulfilled physical activity ambitions. The art of balancing duties and activities was demanding for all participants, and the perceived physical activity constraints appeared similar across the two socioeconomic status groups; however, domestic physical activity was emphasised in breast cancer survivors with low socioeconomic status, while their high-socioeconomic status counterparts reflected more energy in their physical activity descriptions. Useful information about socioeconomic differences, which would not be possible with a traditional questionnaire alone, emerged from the mixed-methods approach. Although the possible different physical activity routines and experiences across socioeconomic status groups among breast cancer survivors did not necessarily lead to different physical activity

levels, future rehabilitation services for breast cancer survivors could benefit from expanding the perspectives of physical activity to better serve the diverse socioeconomic groups.

Paper II demonstrates the benefits of using multiple methods when studying self-reported physical activity among breast cancer survivors across socioeconomic status groups. The study supports the hypothesis that physical activity is performed and experienced differently across socioeconomic groups and that the social practice of physical activity may affect reported physical activity levels because total physical activity may be distributed differently across household-, transporting-, occupational- and leisure-time physical activity dependent on the socioeconomic status group. At the same time, some of these physical activity domains are excluded from the calculations. Differences in physical activity practices could possibly translate to different adherence rates in treatment interventions, including physical exercise, to benefit women with a higher socioeconomic status.

Paper III

Do breast cancer patients manage to participate in an outdoor tailored physical activity programme during adjuvant breast cancer treatment?

In Paper III, the purpose was to report rates of adherence to the supervised exercise sessions and the unsupervised at-home-registered physical activity in a location-determined sub-sample of a randomised controlled, 12-month outdoor physical activity intervention trial for newly diagnosed breast cancer patients (the EBBA-II-study). Differences in adherence between participants with high and low socioeconomic status were analysed alongside health-related variables, such as maximal oxygen consumption ($\dot{V}O_{2max}$ ml×kg-1×min-1) and comorbidity. We identified 36 completers and 11 dropouts for further analyses. These analyses showed that dependent on whether dropouts were included or not, the overall mean adherence to supervised exercise sessions ranged between 64% and 80.6%. In the case of the unsupervised physical activity, the adherence rates of completers and non-completers were 230% (SD 213) and 234% (SD 350), respectively. Beyond that, the quarterly adherence rates were rather stable; however, a slight decline in attendance rates throughout the intervention period was observed. Seasonal variations appeared to coincide with national standard holiday periods.

None of the socioeconomic variables correlated significantly with adherence to supervised exercise or with adherence to unsupervised at-home physical activity. Compared with the group of completers, the dropouts had statistically significant lower income. Non-parametric tests of distribution differences in adherence to both parts of the physical activity intervention for several baseline variables, including socioeconomic status, did not produce any statistically significant results; however, a closer look at the sample revealed that it proved to lack social representativeness, and thus our results suffered from reduced external validity.

Paper III addresses the importance of transparency in clinical trials in terms of reporting participants' characteristics at the baseline and throughout the intervention to better gain knowledge regarding which groups of patients need extra follow-up or may not be suitable for the physical activity intervention. Although the results showed no statistically significant relationship between adherence to group exercise and socioeconomic status, the sample was too small and too socially homogeneous to draw a conclusion.

6. Discussion

Physical activity is considered an important yet socially patterned determinant of health [91-95]. Unfortunately, the effect of physical activity-related actions targeting lower socioeconomic groups has failed to materialise at the same time as social inequalities in health persist globally as well as in welfare states, such as Norway [6,267]. As an attempt to bring a new perspective to health inequalities, the present thesis illuminates the possible implications of common methodological practices in physical activity research as an explanation for the scientific understanding of differences in physical activity between socioeconomic groups. The specific overall query was whether methodological decisions in the measurement of physical activity affect reported physical activity behaviours differently between socioeconomic groups. For the studies, we have investigated how the complex concept of physical activity is used in research; how alternative methods of collecting data may bring new information to the scientific understanding of physical activity across socioeconomic groups; and whether and how a physical activity intervention trial suits socioeconomic groups differently.

Physical activity research within the population of breast cancer survivors, including newly diagnosed breast cancer patients and women who were diagnosed with breast cancer 7-8 years before study enrolment, has been studied as a case; however, it must be noted that although breast cancer research including physical activity has been regarded as interesting due to the socioeconomic distribution within the population of breast cancer survivors, the specific branch of research was not chosen as a case because it represents a field of particularly poor physical activity research. Findings in the present thesis may well apply to studies including physical activity within a host of other diagnostic groups.

Socioeconomic status and physical activity

To determine whether methodological decisions affect reported physical activity behaviour differently between socioeconomic groups, each included paper examined socioeconomic inequalities through different aspects of physical activity. Similar to previous studies on the topic, the initial and somewhat shallow interpretation of the findings that occurred across Papers I-III was that there may be differences in physical activity between

socioeconomic groups; however, subsequent analyses showed that socioeconomic differences do not necessarily occur due to the amount as much as to the other aspects of physical activity and that a predominant focus on leisure-time physical activity may have distorted the depiction of real differences in total physical activity.

First, of all studies included in Paper I, 41% reported a predominantly positive relationship between physical activity and socioeconomic group (thus indicating that high socioeconomic groups were more active), whereas 16% of the studies reported that low-socioeconomic groups were more physically active. A total of 38% of the studies reported both positive and negative associations between the two variables. Thereafter, Paper II showed a socioeconomic difference in physical activity intensity as the group of breast cancer survivors with higher education reported higher intensity in their activities in the questionnaire, and a higher percentage of breast cancer survivors in the high socioeconomic group were characterised as physically 'active' compared to breast cancer survivors in the low socioeconomic group. They also logged more exercise sessions during the week and narrated more strenuous activities in the interviews. Such findings are consistent with previous studies of breast cancer survivors, showing positive associations between recreational physical activity and higher education [236,237] or living in high-socioeconomic status neighbourhoods [238]. In Paper III, there was a statistically significant difference in income level between the group of completers and the group of patients who withdrew from the physical activity intervention. Gokal et al. [247] found a similar association between being dropouts and being unemployed or having lower education. Although the studies differ regarding the choice of socioeconomic status indicator, both Gokal et al.'s study and our study indicate an association between socioeconomic status and the odds of completing a physical activity intervention. From these results, although Paper II also showed that housing physical activity formed a larger part of the reported total physical activity in breast cancer survivors with lower socioeconomic status compared to those with higher socioeconomic status, and no significant association between adherence to the intervention and the indicators of socioeconomic status were found in Paper III, one could easily be led to believe that there are socioeconomic inequalities in physical activity levels in general, and the group of breast cancer survivors, proceeding to develop physical activity interventions targeting low socioeconomic groups.

A traditional and reasonable explanation of such reported social inequalities in physical activity is the unequal access to resources required to perform such activities. Being able to afford sports team memberships, tickets to a swimming pool or equipment considered necessary to perform a specific physical activity, for example, is socially patterned. From this perspective, household income plays a prominent role, and there are no reasons to believe it would be different among breast cancer survivors. Furthermore, lower income is often associated with poorer living conditions and neighbourhoods with less opportunity for outdoor physical activity, which might be the case in the previous breast cancer study of Keegan et al. [238]. There is also no shortage of studies showing that educational level affects physical activity levels, breast cancer survivors being no exception (e.g. [236,237]). Moreover, the physical activity intervention under the auspices of a university hospital reported in Paper III included free attendance to exercise groups, and the only apparent equipment required was a pair of training shoes and comfortable clothes. Regardless, other expenses, such as costs related to transport and work absence, or departure from strict working time arrangements prevented some patients from participating in our trial, and thus the explanation regarding a lack of resources seems valid.

However, physical activity is complex and must be examined accordingly. So also is the socioeconomic status variable. From an earlier published review of previous studies of the relationship between socioeconomic status and physical activity among adolescents [17], we learned that there was no clear evidence of a positive relationship between the two variables and that there was a large variability in the choice of physical activity measurements as well as in measures of socioeconomic status. We were also reminded that a rather narrow understanding of the concept of physical activity and exercise might be associated with different indicators of socioeconomic status [18]. The main aim of Paper I was therefore *not* to clarify whether high socioeconomic groups were in fact more physically active than low socioeconomic groups but rather to identify variations in findings across previously published studies on the subject and to examine whether these findings were linked to which physical activity domains had been investigated. The question of whether common decisions in the measurement of physical activity affect reported physical activity behaviours differently between socioeconomic groups thus remained a key topic throughout all three papers (I-III).

Differences in reported physical activity behaviour and methodological practices

The concept of physical activity should be properly defined and operationalised when under investigation and must correspond to what the researcher intends to study [99]. In addition, the operationalised physical activity concept must apply to all subgroups included in the material. More specifically, the distinctions between total physical activity and leisure-time physical activity only and between leisure-time physical activity and physical exercise according to the way these concepts are defined by Caspersen et al. [100], for example, determine which part of the overall concept of physical activity is studied. The structured meta-analyses of scientific publications that was conducted in Paper I, when the results from the included studies were organised according to distinguishable physical activity domains, in some respects altered our initial findings of the relationship between socioeconomic status and physical activity. The positive relationships between high socioeconomic groups and physical activity levels that were reported were in fact related to leisure-time physical activity only, while a large preponderance of studies that examined occupational physical activity reported that low-socioeconomic status groups were more physically active. Regarding our findings, Bradley concluded rather clearly in a recent journal letter that *'no such association exists for all other types of physical activity* [i.e. other than leisure-time physical activity] — *individuals from low socioeconomic groups might actually be more active'* [268]. Hence, our results lend further support to findings reported in Beenackers et al.'s review of European studies [12], which showed no clear relationship between physical activity and socioeconomic status and that studies reporting physical activity during work reported that low-socioeconomic groups were more physically active than high socioeconomic groups.

Paper II provides a follow-up example of the implication of a biased focus on leisure-time physical activity. The finding that a higher percentage of breast cancer survivors were characterised as 'active' compared to breast cancer survivors in the low socioeconomic group was based on data related to leisure-time physical activity. When we included other physical activity domains in our calculations, the reported proportions of total physical activity in breast cancer survivors with a lower rather than a high socioeconomic status increased. A qualitative study reporting different motivations, routines and breadths in preferences in terms of type of physical activity between women in different socioeconomic groups [155] highlighted that these

groups of women do not necessarily share the same physical activity interests, independent of the breast cancer experience. Unfortunately, inaccurate instructions to the participants about the level of logging details during work, probably combined with the previously demonstrated common misconception that physical activity equals exercise [107,108], may have contributed to incomplete data on occupational physical activity in our study. Findings from previous studies that breast cancer survivors often suffer from fatigue after breast cancer treatment [176], which likely prevents them from returning to work [269], and the fact that many participants in our material were retired reduced the possibility of collecting data on occupational physical activity; however, none of the participants in Paper II logged such activity, and thus no such data were available for analysis. Nevertheless, perhaps there was a slight indication that occupational physical activity is important for total physical activity, considering that women in the lower socioeconomic group stated that previous workloads had worn them out and possibly affected their current level of physical activity. This is consistent with the previous findings of Ball et al. [155], who identified physical working activity as a reason for less leisure-time physical activity in women in the low-socioeconomic group. Interestingly, there seems to be a lack of studies investigating socioeconomic differences in physical activity that include occupational physical activity data among permanent breast cancer survivors. A more complete set of activity-log data including all physical activity domains in our study could have enabled a better test of the proportion of the occupational and other physical activity domains across socioeconomic status groups, and it may have lent better evidence to previously claimed shortages in common physical activity questionnaires in terms of total physical activity.

Furthermore, from Paper III, in which only leisure-time physical activity was subject to analysis, we found little evidence based on available data to claim socioeconomic differences in adherence to the prescribed physical activity intervention protocol. These results corresponded to previous studies examining the relationship between educational level and participation [270] and deprivation (residential postal code) and adherence [271] in two different exercise trials for breast cancer survivors, respectively. Nevertheless, relevant to the present discussion is the fact that breast cancer survivors with a low socioeconomic status in Paper III participated in the trial to a lesser degree than their high socioeconomic counterparts. The causes of such inclusion bias have previously been discussed and suggested to be amended by participation payments [272]. Based on findings in Paper I and Paper II,

that low socioeconomic groups report lower levels of leisure-time physical activity than high socioeconomic groups do, it is reasonable to assume that lower participation rates in the former groups are not only due to personal economy but also due to the fact that leisure-time physical activity simply does not fit all.

Although high socioeconomic groups may have higher levels of physical activity during leisure time, total physical activity levels include active transport, housing physical activity, occupational activity and all other daily-life activities as well [100]. While Papers I-III produced results on leisure-time physical activity, they yielded less information on the remainder of domains, thus likely being representative of the research field. Hence, because a number of studies have operationalised physical activity in terms of leisure-time physical activity and thereby do not include other domains of physical activity, the knowledge of physical activity differences between socioeconomic groups may be inaccurate. Admittedly, an effort has recently been made to develop valid questionnaires that measure occupational physical activity [273]. In addition, occupational, household and transport physical activity have been included as counting components of the recommended amount of physical activity in the updated WHO 2020 guidelines on physical activity and sedentary behaviour [90].

At this point, while calling for research that includes domains of physical activity other than leisure-time physical activity, it seems appropriate to call attention to the 'physical activity paradox' introduced by Holtermann et al. [274,275]. The authors advocate that although physical activity is found to have a positive impact on many health outcomes, the health effects are documented only for leisure-time physical activity, whereas high occupational physical activity, particularly in men, in fact may reduce cardiovascular health. In addition to physiological explanations affecting cardiorespiratory fitness, lack of sufficient recovery time and limited worker control have been suggested as reasons for the detrimental effect of occupational physical activity. These points could legitimise the large focus on leisure-time physical activity compared to work-related physical activity in physical activity research [274]; however, in the context of social inequalities in physical activity and health, they also illustrate the importance of understanding physical activity as more than simply the quantified levels of leisure-time physical activity.

Returning to methodological practices within physical activity research, an additional finding in Paper I was that a majority of the studies included had applied physical activity questionnaires in the measurements of physical activity. Physical activity questionnaires have been found to lack validity because they often result in over-reporting physical activity levels [116,120] and are insensitive to behavioural changes or suffer from problems with the confusion of concepts across age, gender and cultures [118] and often lack information on physical activity domains [121]. In addition, what seems to have been even less discussed is the impact of the type of physical activity that does not fit into any domain (so-called daily-life physical activity) but which is decisive in the total physical activity account; however, the most frequently used physical activity questionnaires do not assess such daily-life physical activity. The findings in Paper II that breast cancer survivors in the low socioeconomic group reported more physical activity within other domains than leisure-time physical activity was revealed by means of a mixed-methods approach that was chosen for the purpose of comparing, and assumedly, complementing the questionnaire. Although it is an epistemological and ontological question whether researchers prefer one specific method to another, if leisure-time physical activity is more relevant to higher socioeconomic groups, a questionnaire asking for leisure-time physical activity data based on a likely socially determined prior understanding of the concept may not be as suitable for investigating differences in physical activity across socioeconomic groups. While the interviews provided important information on different socioeconomic experiences with physical activity, the activity-logs added relevant information about possible different socioeconomic physical activity routines. If we had limited our study to assessing physical activity from questionnaires exclusively, only fractional information about socioeconomic differences would have been imparted.

Furthermore, the decision about designing RCTs that include physical activity interventions is of course legitimately grounded in the interest of studying the effect of physical activity; however, other consequences relevant to socioeconomic differences arise from such a research practice. First, designing the physical activity intervention implies a choice of which physical activity domain to include in the protocol, which in turn leads to the second point: the fact that the intervention, such as the one in Paper III, often includes leisure-time physical activity, which may have affected participation rates among breast cancer survivors with low socioeconomic status, as also suggested. Hence, the design of an exercise intervention may affect the

socioeconomic distribution of participants. It is argued that one of the most serious problems with RCTs is the criteria for including participants, which often result in the exclusion of those of poorest health [133]. The excluded patients are therefore often those who likely would benefit most from the intervention. In Paper III, we explain that the household income level among breast cancer patients who participated, but did not complete the physical activity intervention, was statistically significantly lower than the income level of those who completed it; however, there was no significant association between any of the socioeconomic status variables and adherence rates in our study, leading to the assumption that the trial was equally feasible for all socioeconomic groups.

An explanation of the lack of a significant difference in adherence between socioeconomic groups, is the fact that the group of patients that was included was not adequately representative with respect to socioeconomic status. Any analysis of socioeconomic differences would not be valid if the analyses are based on an erroneous sample distribution of socioeconomic groups. Based on previous findings that individuals from lower socioeconomic status groups are less inclined to participate in research studies compared to individuals from higher socioeconomic groups [165,276], it is reasonable to believe that our findings regarding a lack of representativeness apply to other studies as well. In fact, preliminary results from an unpublished sequenced literature analysis of 37 published adherence reports from physical activity intervention trials among acute breast cancer survivors would add relevant knowledge to this discussion [277]. Initially, a total of 10 papers (21%) in the study had to be excluded from the material due to lacking any reporting of participants' socioeconomic status whatsoever. Reporting patient characteristics, including educational and income level or occupational status, is crucial to external validity, mainly because it enables the reader to evaluate sample representativeness [133,161], especially for the actual main dependent variable in the study; however, most relevant is the degree of representativeness in the studies included. When we rearranged the educational group levels so that the highest level included participants with at least one year of technical, college or university education, the groups of patients holding the highest education ranged from 16% [278]–81% [279] of the study samples (mean 54%, SD 18). Although the studies were conducted in countries with different social structures regarding socioeconomic distribution and the prevalence of breast cancer across socioeconomic groups differs between countries, these preliminary analyses support the suggestion imparted in Paper III that low socioeconomic status groups are

underrepresented in these studies. Unfortunately, the number of studies that reported associations between socioeconomic status and adherence to the physical activity intervention is far too small to perform an analysis of the associations between representativeness and the reported relationship between socioeconomic status and adherence. Therefore, pending representative samples, the question of adherence to physical activity interventions across socioeconomic groups, and thus physical activity intervention feasibility, in the group of newly diagnosed breast cancer survivors remains unanswered.

The points discussed seem to reflect a stepwise social exclusion in physical activity trials. First, the patients who do not embrace leisure-time physical activity are excluded from trials because they refuse to participate. Next, ineligible patients are excluded due to prerequisites, i.e. they do not qualify for participation. Then, dropouts withdraw from the trial for several reasons (they regret participating), and finally, participants who complete the intervention but who struggle with participation have poor adherence rates, thus yielding missing data. If such shedding, as suggested, is socially patterned throughout the entire research process, the external validity decreases successively. The fact that Paper II reports higher levels of leisure-time physical activity than expected due to late-affects from breast cancer treatment in breast cancer survivors and that unclear socioeconomic inequalities in leisure-time physical activity levels may also be explained by a socially misrepresented study sample. In both papers, the sub-analyses of socioeconomic differences may be less valid because the socioeconomic distribution in the study samples does not reflect the distribution in real life.

A related third point is that many RCTs report adherence rates without including participants who withdraw from the intervention, despite the fact that missing data has an influence on the adherence rates presented [146]. When we excluded withdrawals from our analysis in Paper III, the adherence rates increased by 27%. These numbers demonstrate that reporting adherence rates from completers exclusively would distort the depiction of the real-life targeted patient group. Another statistical alternative could have been the ‘intention-to-treat-analysis’ (typically, ‘last registration carried forward’) [280]. This approach considers data from non-completers and thus provides an underestimated rather than an overestimated calculation of the effect of the intervention; however, this alternative seemed inapplicable in adherence analyses because non-attendance after withdrawal in principle would have been treated as attendance. In both cases, the procedure would withhold

valuable information and could thus lead to concealed limitations of the intervention's feasibility. Therefore, we would have failed to see the social patterns among dropouts and participants with low adherence.

Moreover, a wide variety of adherence calculations have been identified across studies [141,142], although the choice of calculation model clearly affects the reported adherence rates. Our adherence report from the group exercise sessions in Paper III was based on a percentage of full attendance defined as attending 80 group sessions. If we had used a different way of calculating adherence in our study, such as the number of participants who completed 90% of the intervention per protocol divided by patients in the intervention group (as for example in Mijwel et al. [185]) or the number of participants who were attending both days every week during a twelve-month period (albeit an unrealistic goal), quite different adherence rates would have been reported. Indeed, it appears reasonable to allow for a certain degree of sickness absence and to subtract a given number of weeks of holidays from the calculation basis in studies of patients undergoing a demanding breast cancer treatment; however, by making the calculation basis convenient, and likely excluding dropouts from the analysis, the adherence rates alter greatly, thereby leading to possible misinterpretations of true intervention feasibility.

So, does it matter? The results reported in Papers I-III give reasons to claim that the common methodological practice in the measurement of physical activity affects the reported physical activity behaviours differently between socioeconomic groups. Given that these results could be generalised to the population in general and do not apply to breast cancer survivors exclusively, what could the consequences be?

Implications for future policy and research

In view of the differences between socioeconomic groups, a prompt question is whether common contemporary physical activity research could be considered unjust to low socioeconomic groups. According to WHO's definition of social health equity, ideally, everyone could attain their full health potential, and no one should be disadvantaged from achieving this potential due to their social position [28]. A disproportionate focus on leisure-time physical activity in physical activity research results in incomplete knowledge of how socioeconomic status relates to physical activity. Because leisure-time physical activity seems to be more common in high

socioeconomic groups, the common physical activity research practice produces considerable knowledge regarding the kind of physical activity that applies to these groups at the expense of physical activity in low socioeconomic groups. Public intervention programmes introduced as a means to improve health in the population in general are based on such knowledge about leisure-time physical activity, and thus they are less relevant for the less affluent group. Consequently, these interventions provide more health-improving physical activity for high socioeconomic groups, which are already advantaged with respect to health. Hence, the socioeconomic health gap likely widens. Furthermore, treatment interventions that include physical exercise or other leisure-time physical activities risk a stepwise dropout effect from participating patients with a low socioeconomic status. On one hand, the consequence of such attrition bias is that the results may be valid only for individuals similar to those who have participated and completed the intervention, and on the other hand, that the treatment method (i.e. physical exercise) is less applicable among patients who belong to the same group as those who withdrew. Similarly, rehabilitation programmes designed with physical exercise for the purpose of improving health among patients would likely better suit patients with a higher socioeconomic status than their low-socioeconomic status counterparts. These mechanisms are in line with the fundamental cause theory [68,69,71] in that people with more resources benefit more from physical activity research because methodological decisions in the measurement of physical activity serve their interests more than they serve the interest of low socioeconomic groups.

The first part of 'The Inverse Health Care Law' states that *'the availability of good medical care tends to vary inversely with the need for it in the population served'* [26] (p. 412). The essay 'The Health Care Law Today' describes the situation as it was in 2002 [281]. A key point was how individuals who were less advantaged still received poorer health services compared to individuals in higher socioeconomic groups. Later papers have referred to the inverse health law in similar manners to describe how individuals in less affluent neighbourhoods are disadvantaged when accessing health services, consultation length, quality of service, likelihood of diagnosis, referrals to specialists or secondary and tertiary services, waiting time, health promotion clinics and patient enablement and more, despite higher rates of comorbidity, psychological distress and chronic illness (e.g. [282-284]). Adapted versions of the law, such as 'the inverse prevention law' introduced by Lorenc et al. [81], recognise that those in most need of

benefitting from preventive interventions are least likely to receive these interventions. Previous research and findings presented in the present thesis give reasons to at least warn against an incipient analogue: 'inverse physical activity research law'. Contemporary physical activity research, introduced with the intention to serve the whole population, tends to generally serve high-socioeconomic groups for better health rather than low socioeconomic groups, who in general may be more in need of benefitting from (socially valid) physical activity research.

The fact that the availability of time seems to be relevant for socioeconomic differences in physical activity is likely underestimated in previous research on the subject. In general, while leisure time became a key element in Paper I, the art of balancing time in the context of suffering late-effects from breast cancer treatment was an essential aspect of Paper II. Throughout Paper III, time also appeared to be a crucial element for the ability to participate and adhere to the physical activity intervention. More specifically, one of the most important reasons for not participating in the trial reported in Paper III, or for withdrawing from the intervention, was lack of time or family or work constraints, which likely demand time. Due to an overrepresentation of participants from higher socioeconomic groups in the analysed material, it is reasonable to assume that non-participants on average were from lower socioeconomic groups. In Paper II, log and interview data reflected differences between the lowest and the highest socioeconomic groups in physical activity routines. Ball et al.'s [155] identification of different physical activity routines and different causes of lack of time to engage in physical activity between socioeconomic groups of women is consistent with our findings. The importance of time as a health resource, especially among women, as emphasised by Strazdin et al. [72,73], thus seems supported by our and Ball et al.'s results. The joint theoretical framework of time-geography and Bourdieu's theory of social practice, which is found in Pred [75], could be a useful perspective on these matters but is left to future research.

Social inequality in health has been a target for Norwegian political health strategies [22,23] and an issue in national policies targeting specific diagnoses, such as cancer [25]. The WHO's goals for equity in health would be to eliminate all systematic social differences in health, whereas equity in health care would be achieved if available health services are closely matched to the level of need [80]. Similarly, the goal for social equity in health research, which forms the evidence on which our health services are based,

would be if research derived evidence applies equally to all socioeconomic groups. When targeting social health inequalities through health research, we must respond to the fact that people with different socioeconomic backgrounds have unequal starting points and critically reflect on the tendency of using leisure-time physical activity as 'the one-size-fits-all-cure for everything'. If it is true that individuals in different socioeconomic groups perform and experience physical activity differently, it may be unsuitable to implement health promotional physical activity actions equally across all socioeconomic groups. What also follows rather clearly is that we cannot apply the same physical activity research designs to all socioeconomic groups, claiming the results apply equally to every socioeconomic group. As pronounced by Dressel [285], perhaps social health equity is not achieved by treating everyone equally but rather '*by treating everyone equitably, or justly according to their circumstances*'. This also seems to be the case for physical activity research. Future physical activity researchers are advised to include all physical activity domains in studies of socioeconomic differences, and researchers should resolve and include the effect of (not) having time as a critical socioeconomic resource in addition to the 'traditional' socioeconomic resources (i.e. education and income) as well as should consider different interests and motivations for physical activity across socioeconomic groups in planning research and treatment or rehabilitation interventions that include physical activity.

Strengths and limitations

The limitations and the strengths of the present study are relevant for future research. In this respect, Paper I is a study of published, international research on both men and women, excluding patient groups, whereas both Papers II and III are studies reporting original data from female study samples of a specific diagnostic group in Norway. Due to differences in the levels of analysis, gender and health status, it could be argued that the first paper is a mismatch to the others; however, the Norwegian breast cancer population was studied as one of the insurmountable amounts of populations in which physical activity research is conducted and thus was treated as a representative case suitable for the research questions that arose from Paper I. On the other hand, studying a case to examine a broader research field entails a question of generalisability. Although the practices are assumed to be similar within much physical activity research, we do not know for sure that our results can extrapolate to other patient groups or to the population in general. That said, there are no reasons to believe that the tendencies found

in our material would have come out less clear had the study been conducted on the general population. Similar studies in other subpopulations should be conducted to lend more evidence to the present findings.

Moreover, a subgroup analysis of studies reporting on gender differences in Paper I showed that although men and women had similar, positive associations between socioeconomic status and physical activity in the domain of leisure-time physical activity, the negative relationship that was found between socioeconomic status and occupational physical activity in men was less clear for women. Based on these findings, the lack of evidence about socioeconomic differences in occupational physical activity produced in Papers II and III was likely obvious beforehand; however, it is not unlikely that the previous lack of evidence of an association between socioeconomic status and occupational physical activity in women is in fact due to the occupational physical activity (and other physical activity domains apart from leisure-time physical activity) being less studied in physical activity research among women. Therefore, a shortcoming in our material is likely the limited data on occupational physical activity.

Furthermore, the articles on which we based our results in Paper I were published between 2000 and 2014. Subsequent analyses in the study showed that more recent published articles more often indicated negative relationships between socioeconomic status and physical activity, a trend which was interpreted as an increased usage of other physical activity domains in addition to leisure-time physical activity. Apparently, no review based on articles from 2014 and 2020 has been published supporting this hypothesis; however, increased consciousness of the significance of occupational physical activity may be a token of a new trend in physical activity research that includes more than leisure-time physical activity. Nevertheless, today's knowledge must be understood in light of research of the past.

Lastly, the outlined challenges in measuring physical activity also applies to the physical activity data in the included papers. Therefore, our conclusions about socioeconomic differences in physical activity may not be completely valid. Considering the overall purpose, however, anything else would not have been of value for the present thesis to analyse.

Conclusions

The present thesis aimed to illuminate possible implications of physical activity research as explanations of many of the often-reported differences in physical activity levels between socioeconomic groups. Methods frequently applied in the scientific measurement of physical activity were assessed to determine whether they affected the reported physical activity behaviours differently between socioeconomic groups. Operationalisations of the concept itself, different data collection methods, and research design were studied. The practice of mostly measuring leisure-time physical activity at the expense of other physical activity domains seems to have contributed to an overestimation of the positive relationship between physical activity and socioeconomic status. The relationship between physical activity and socioeconomic status seems to be mainly between leisure-time physical activity and high socioeconomic status. Low socioeconomic groups may even be more active in occupational physical activity; however, it remains unclear which socioeconomic group is more physically active in total. Also, an invariant usage of questionnaires, which most often measure leisure-time physical activity levels, likely amplifies the unfavourable emphasis on leisure-time physical activity. Due to the focus on leisure-time physical activity, such questionnaires may conceal important information on total physical activity. Furthermore, information about social differences in other aspects of physical activity, such as routines and experiences, are mostly overlooked. Combinations of data should be applied in physical activity research to ensure relevant information about all socioeconomic groups, including time-geographical data capturing vital socioeconomic differences in time constraints. Lastly, the typical randomised exercise trial may be more feasible and thus more beneficial to high socioeconomic groups, albeit the evidence is not clear due to a sample homogeneity in disfavour of patients with a lower socioeconomic status. Hence, the treatment method may be less effective on low socioeconomic groups, besides the exercise intervention study results may suffer poor external validity at the expense of low socioeconomic groups.

More research is needed before it can be stated that physical activity research is in fact amplifying social health inequalities. However, the present thesis indicates that there are reasons to mind the pitfalls of physical activity research where an eagerness to achieve efficient medical improvements could overshadow the fact that certain social groups do not fit into the framework of such treatment.

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Papers I – III

Paper I

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Review

Are Differences in Physical Activity across Socioeconomic Groups Associated with Choice of Physical Activity Variables to Report?

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Abstract: Despite being challenged in recent years, the hypothesis that individuals of higher socioeconomic status (SES) are more physically active than their lower SES counterparts is generally considered a fact. Recent reviews, however, have suggested that differences across groups might be related to which physical activity (PA) domains have been investigated. In the present review, searches for relevant studies were performed in the MEDLINE, ISI Web of Knowledge and SPORTDiscus databases. Search terms included "socioeconomic", "socio-economic", "socio economic" and "social class" to meet all variations of the variable "socioeconomic status" in combination with the term "physical activity". Studies were included when applying the dimensions of intensity, frequency, type/mode, and duration in measuring PA. Fifty-six studies were included and were subsequently split into four PA domains: transport PA (TPA), occupational PA (OPA), housing PA (HPA) and leisure time PA (LTPA). It turned out that the positive relationship held only for LTPA, whereas the relationship was non-existent or even opposite for all other domains. It is concluded that the assumed positive relationship between SES and PA is mainly a relationship between LTPA and SES. It is further suggested that the PA domain should always be considered when studying said relationships.

Keywords: lifestyle; social position; socioeconomic status; physical activity; activity domains; review

1. Introduction

It has long been assumed that there is an association between socioeconomic status (SES) and physical activity (PA) in that people of high SES are more physically active than those of lower SES (see, for example, [1,2]). Such a difference across socioeconomic groups has been touted as a cause of health-related differences and used to justify advocacy for the introduction of interventions targeted at increasing levels of PA in lower socioeconomic groups [1,2].

More recently, however, several papers have emerged questioning this relationship, among them the reviews by Gidlow, Johnston, Crone, Ellis, and James [3]; Beenackers, Kamphuis, Giskes, Brug, Kunst, Burdorf and Lenthe [4] and Stalsberg and Pedersen [5]. Beenackers et al. [4], in fact, found that in studies reporting occupational PA (OPA), low-SES groups came out as more active, whereas the results were similar across SES groups for active transport. The only domain in clear favor of high-SES groups was leisure-time PA (LTPA). For total PA, the picture was mixed, with about the same number of studies reporting each way. Gidlow et al. [3], although reporting a clear effect of SES when comparing the most extreme (highest and lowest) SES groups, reported relatively mixed results

for the remainder of the data. Gidlow et al. [3] discussed problems with the operationalization of the SES variable but reported that education was most commonly used and seemed to produce the most stable relationships. Stalsberg and Pedersen [5] identified similar methodological problems with both variables (PA and SES) as mentioned above and revealed also that more than 40% of studies on adolescents had found no differences in PA across SES groups. A few even reported opposite results with the low-SES group as more active (see [5] for details).

The common denominator of the mentioned studies was that they pointed to variations in relationships across PA domains and argued that differences across socioeconomic groups might be restricted to differences in organized LTPA, whereas other PA domains such as transport PA (TPA), occupational PA (OPA) and housing PA (HPA) had been somewhat overlooked. That there would be a difference in LTPA across socioeconomic groups is perhaps less surprising, considering that individuals of low SES more often have physically demanding occupations, with heavy and repetitive work [6], longer work hours, and evening and nightshift work more often [7]. Thus, individuals of low SES have less leisure time and less energy to participate in LTPA. Furthermore, organized LTPA is often costly, hence further decreasing the possibilities for participation in organized LTPA for low-SES individuals. True enough; studies confirm that individuals of higher SES participate more frequently in organized LTPA. Hence, interventions including organized LTPA may be less helpful to level out social inequalities in health-related variables unless they focus on increasing access for those who cannot otherwise afford it [8].

Taken together, the mentioned findings suggest that reported differences in PA levels across socioeconomic groups might be biased by an undue focus on LTPA. Stalsberg and Pedersen [5] concluded that although a majority of studies reported a positive relationship between high SES and PA, the relationship was far less clear than what was usually touted. Furthermore, high PA among high-SES groups reported in studies was overwhelmingly LTPA, a fact Palma and Assis highlighted [9] in a commentary. These authors argued further that the whole field of research on PA and health was biased by the fact that researchers were all from developed countries and studied variables that were relevant for individuals in such countries. Palma and Assis concluded that the results of such research painted an unrepresentative picture of the field and, thus such findings would be less relevant for developing countries. Del Duca, Nahas, Garcia, Silva, Hallal, and Peres provided an elegant example, of the importance of considering multiple PA domains. In their study, when adding active commuting to the mix of PA, nearly twice as many individuals adhered to PA recommendations than when only LTPA was counted [10].

In addition, comparing only the number of hours, or minutes, of PA across SES-groups does not provide sufficient evidence for conclusions about health issues. Beckvid-Henriksson, Franzén, Elinder, and Nyberg [11] found, for example, that children from low-SES families were more physically active compared with their high-SES counterparts. Despite this fact, they were more often obese and overweight. The authors thus suggested that one should examine other variables such as diet to identify explanations of health differences across socioeconomic groups.

As both Gidlow et al. and Stalsberg and Pedersen have stressed, considerable methodological challenges plague studies of SES and PA [3,5]. Because both SES and PA are notoriously difficult variables to operationalize; their relationship is similarly difficult to establish, and demands considerable attention to numerous mediators (see, for example, [8,10]). Although Gidlow et al. first and foremost discussed challenges related to SES measures [3], Stalsberg and Pedersen, inspired by Rice and Howell [12], underscored the significance of measuring several dimensions of PA [5]—namely *frequency* (the number of PA events during a specific period), *intensity* (physiological effort associated with participating in a particular type of PA), *duration* (time of participation in a single bout of PA) and *type* of activity. In their paper on methodologies used to assess PA, Warren et al. reiterated the argument: that it is difficult to obtain a valid measure of PA [13].

Inspired by the mentioned studies, especially the work of Beenackers et al. [4] who clearly demonstrated the significance of differentiating between domains of PA, the present review set out to

investigate whether the assumed positive relationship between SES and PA may have been somewhat overestimated because the majority of studies on the topic have reported data on LTPA. There are two notable differences between Beenackers et al.'s study and the present one. First, Beenackers et al. restricted their study to European adults, whereas we imposed no such restrictions given Stalsberg and Pedersen's [5] observation of regional differences outside Europe, and given Palma and Assis' [9] suggestion that developing countries were misrepresented in studies of PA. Second, we attempted to present a more standardized operationalization of PA than did Beenackers et al., by applying Rice and Howells' criteria [12]; thereby securing data that would be more comparable across studies.

Our review is not a traditional systematic review as far as it does not seek to synthesize or summarize previously reported results. Instead, the aim was to identify variations in findings across individual studies, and to examine whether these might have stemmed from the selection of PA domains investigated.

2. Materials and Methods

Computerized searches were conducted in the MEDLINE, ISI Web of Knowledge (ISI) and SPORTDiscus databases to identify all relevant articles published from 2000 to 2010. A subsequent search was performed, that encompassed more recent papers (published between 2010 and 2014). To include all variations of the variable "socioeconomic status", the search terms "socioeconomic", "socio-economic", "socio economic" and "social class" were used in combination with the term "physical activity". To exclude studies on children and adolescents, the search limit "19 years plus" was imposed upon the search performed in MEDLINE, and the terms "grownups" and "adult" were added in the ISI search. The search in SPORTDiscus was performed without pre-set boundaries.

The first, relatively open, search (Search 1) returned 1225 articles, many of which, we quickly realized were not relevant whatsoever. We therefore added further limitations, as shown in the search criteria of MEDLINE/PubMed (Search 2) presented in Table 1, which after proving their worth, were applied to all subsequent searches. We have presented Search 1 in Table 1 to illustrate the differences between the two search strategies. By imposing the additional limitations, we avoided sifting through roughly 500 irrelevant titles and abstracts, as well as possible several hundred others in subsequent searches. Ultimately, slightly more than 3400 titles and abstracts were examined to identify studies that would meet the inclusion criteria, and, of those, 385 potentially relevant articles were thoroughly investigated to establish their eligibility according to the criteria.

To be included in the review articles had to report empirical studies with original data, including data from national surveys, that represented adult participants of both genders; address the relationship of SES and PA in their titles or abstracts; apply Rice and Howells' dimensions in measuring PA (i.e., intensity, frequency, type or mode and duration); and be written in English. Studies with the aim of investigating physical inactivity (PIA) that applied an adequate method of assessing the level of PA, were included.

By contrast, articles were excluded if they reported studies with samples of disabled individuals or people with diseases exclusively; reported studies on motor skills; were doctoral **theses,** descriptive or theoretical papers, abstract of books or proceedings, conference papers or reviews; reported intervention studies with only either low- or high-SES groups; reported studies with single-gender samples; reported studies using the SES of the respondents' parents (in the case of for example university students); reported studies that applied fewer than four of the mentioned dimensions in measuring PA (i.e., intensity, frequency, type or mode and duration); or primarily addressed methodological questions.

Each of the databases searched offered schemes for imposing limits on the searches. To ensure that the selections of articles were based on the same criteria, some limitations had to be imposed during the reading process and others using pre-set limitations offered by the database. Limitations imposed on the searches appear in Table 1. The first author performed all searches, and both the two authors

discussed the few articles whose eligibility was uncertain and determined their merit according to the criteria.

Table 1. Search strategies and findings.

	Search Strategy	Articles Identified	Potentially Relevant Articles [1]	Articles Included
MEDLINE/PubMed 2000–2010, humans, English, 19 years plus				
1	Physical activity and (socioeconomics or socio-economic or socioeconomic or socio economic or social class))	1211	not assessed	-
2	*Physical activity and (socioeconomics or socio-economic or socioeconomic or socio economic or social class)) not (disease or depress or injury or pregnant or neonatal or adiposity or cardiovascular or cancer or kidney or iron or schizophrenia or vitamin or calcium or herbal or osteoporotic or rheumatoid or personality or microbial or lipoprotein or lipid or sleep or menstrual or glucose or insulin or coronary or schistosomiasis or diabetes)*	725	136	18
MEDLINE/PubMed 2010–2014, humans, English, 19 years plus				
	Equal to search 2 in Medline	800	64	12
	SPORTDiscus 2000–2010			
1	(Physical activity) and (socioeconomics or socio-economic or socioeconomic or socio economic or social class))	262	69	6
	SPORT DISCUS 2010–2014			
	Equal to search 1 in SPORTDiscus	360	25	5
ISI Timespan = 2000–2010. Databases = SCI-EXPANDED, SSCI, A&HCI.				
1	(Physical activity and (socioeconomics or socio-economic or socioeconomic or socio economic or social class) and (adult or grown up))	260	43	2
ISI Timespan = 2010–2014. Databases = SCI-EXPANDED, SSCI, A&HCI.				
	Equal to search 1 in ISI	1007	48	13
	TOTAL			56

1 The number of potentially relevant articles refers to the number prior to a control of duplicates. Duplicates identified in MEDLINE were deleted from the list if identified in ISI or SPORTDiscus. Articles identified in ISI were deleted if identified in SPORTDiscus.

2.1. Data Extraction

From the studies included in the sample, data relevant to the present review were extracted, and registered the variables *aim of study*, *design*, *sample characteristics* (including gender, age, and nationality), *measures of SES*, and *outcome/conclusions*.

Next, the various measures of SES were categorized by education, income, occupation, neighborhood or other if none of the mentioned categories pertained. In addition, less precisely defined variables (e.g., when income was dichotomized as low or high) were registered. Measures of PA were registered according to the four valid measurement dimensions (i.e., duration, frequency, intensity, type, or mode of PA). Phrases similar to "for at least 30 min at a time" were coded as duration. The question of whether the exercise could be regarded as vigorous or moderate was recorded as a measure of intensity. In some studies, authors had pre-calculated intensity by type of PA, particularly when the terms "moderate" and "vigorous" activity were used or when Ainsworth's code schemas, which classify specific PA by rate of energy expenditure as the Metabolic Equivalent for Tasks (METs) [14], was cited.

2.2. Analysis

Papers were thoroughly reviewed for the directions of relationships reported, although-based also with attention to primary tendencies in the results. The categories of relationships, denominated

as positive (i.e., high-SES groups being more active), negative (i.e., low-SES groups being more active), mixed (both high- and low SES being more active according to type of activity or SES measure) and no relation, were then sorted by continental affiliation (i.e., Europe, North America, South America, Asia, Africa, and Oceania). To minimize the complexity of presentation, studies of PIA reporting more inactivity in lower-SES groups were registered as having reported positive relationships. Studies reporting more inactivity among higher-SES groups were thus categorized as having reported a negative relationship.

Within each geographical cluster, the frequency of studies with positive, negative, mixed or no relationship were recorded for each SES measure applied. Education was applied as a measure of SES in 16 European studies, 10 of which demonstrated a positive, one a negative, four a mixed, and one a non-existent relationship. A similar procedure was performed for the different domains of PA that emerged during the analysis. If results referred to PA guidelines or to several domains of PA combined, they were recorded in separate groups.

Although results from studies of PIA were included in the analysis (more inactive groups considered less active) they were not analyzed as a freestanding group. Studies investigating gender differences were identified and analyzed both in terms of the primary (i.e., total) sample and as males and females separately.

3. Results

The searches returned 56 relevant studies, which were subsequently included in the final sample. Table 1 presents the search strategies and results. Above all, the outcome revealed complexity in the association between SES and PA among adults that adds important nuances to common assumptions about the relationship of SES and PA.

The sample included studies representing 30 nations in total; 22 studies were European, 11 were Asian, nine were North American, eight were South American, five were Oceanian (i.e., Australian) and one was African (i.e., Nigerian). Almost three out of four (41) of the articles had been published during the second half of the period (2008–2014) and a third during the past 2 years. The samples varied widely, from 276 [15] to 55,151 [16], and women were slightly overrepresented in nearly every study. Regarding age composition, the studies' samples were relatively similar; at the extremes, one had a mean age of 22.4 years [17,18] and the other a mean age of 75 years [19]. Except for samples from a few studies with slightly narrower age ranges, samples ranged from 18 to 65 or from 16 to 75 years. Three North American studies had particularly high-age samples of 53–97, 65–80+ and 50–79 years. Most of the studies were based on data from either interviewer- (e.g., telephone) or self-administered questionnaires, with the notable exceptions of van Dyck et al. [20], who complemented their data using accelerometers, and Golubic et al. [21], who combined self-reporting with heart rate and movement censoring. The vast majority of studies (n = 48) used education as an SES measure, whereas occupation was the most rarely applied measure (n = 14). Usually, two or more but no more than five measures were applied in each study to establish SES.

Three fourths of all studies analyzed reported results related to all four dimensions of PA. In 30 of those studies, PA was operationalized as a rate of energy expenditure (e.g., total energy expenditure (TEE) or METs). When results from fewer than four dimensions were reported, intensity was the dimension most often excluded from analysis.

In what follows, four tables are presented describing studies in the sample. Each table describes a different direction of relationships; Table 2 includes studies demonstrating predominantly positive relationships (i.e., high SES groups reported to be more active than low-SES groups), Table 3 includes studies with negative relationships (i.e., low-SES groups reported to be more active than high-SES groups), Table 4 includes studies reporting no relationship, and Table 5 includes studies demonstrating mixed relationships (i.e., positive, negative and non-existent) within the same study. Each table lists articles according to continental affiliation and, thereafter, by year of publication.

Table 2. Studies investigating PA in adults across SES. Positive relationships.

Study	Aim and *Study Design*	Sample	Measures of SES [1]	Outcome/Conclusion
Bernstein et al., 2001	Describe the distribution of PA. *Questionnaires/measures of weight and height*	*n* = 3410 M: 1707 F: 1703 Age: 35–74 SWITZER-LAND	Education: + Income: – Occupation: – Neighborhood: – Other: –	Sedentarism (related to total energy expended) is more prevalent in (. . .) W and lower SES persons [22]
Bertrais et al., 2004	Evaluate the characteristics of subjects meeting public health PA recommendations. *Questionnaire*	*n* = 7404 M: 3404 F: 4000 Age: 45–68 FRANCE	Education: + Income: – Occupation: – Neighborhood: + Other: –	In W, but not M, education level was positively related to meeting Public health recommendations (PHR) (related to METs). Resident location was not related to the probability of meeting the PHR in M, whereas W who did not live in an urban pole were more likely to meet the PHR compared with women who did [23]
Kamphuis et al., 2008	Examine the contribution of neighborhood, household, and individual factors to SES inequalities in sports participation in a multilevel design. *Postal survey*	*n* = 3839 M: 1836 F: 2003 Age: 25–75 HOLLAND	Education: + Income: + Occupation: – Neighborhood: + Other: deprivation	The lowest educated and lowest income group were most likely to report no sports participation. Significant clustering of no sports participation within neighborhoods. Two out of three indicators of material deprivation (crowding or having financial problems) and all three indicators of social deprivation increased the likelihood of doing no sports. In addition, these factors showed higher prevalence among lower SES groups [24]
Borodulin et al., 2008	Investigate the associations of age and education with types of LTPA. *Self-reported questionnaire*	*n* = 4437 M: 1940 F: 2497 Age: 25–64 FINLAND	Education: + Income: – Occupation: – Neighborhood: – Other: –	Education was directly associated with conditioning and overall LTPA in M and W, but no association was found with daily PA. For both M and W, low education group reported significantly less conditioning activity and overall LTPA than the middle and high education groups [25]
Kwaśniewska et al., 2010	Analyze the epidemiology of TPA and investigate the relationship between TPA and SES and lifestyle. *Questionnaire*	*n* = 7280 M: 3747 F: 3533 Age: 20–74 POLAND	Education: + Income: + Occupation: – Neighborhood: – Other: –	Prevalence of walking/cycling less than 15 min/day was the highest among those with secondary education (both M and W), with the lowest income in M and with the monthly income 130–260 Euros/month in W. Active transportation lasting 15+ min/day was most prevalent in M and W with monthly income above 260 Euros/month. Among both M and W commuting 30+ min/day there was a domination of persons with university education [26]
Stringhini et al., 2011	Examine whether health behaviors are equally important mediators of the SES-health associations in different cultural settings. *Questionnaire*	*n* = 30,933 M: 21,906 F: 9027 Age: 35–55 UK/FRANCE	Education: + Income: + Occupation: + Neighborhood: – Other: –	The difference in prevalence between highest and lowest occupational group was 15% for being PIA. Participation in the lowest occupational group compared to those in the highest were more likely to be (. . .) PIA [27] (Only Whitehall II, phase I (the British study) is included due to the PA measure criteria)
Łobaszewski et al., 2011	Evaluate the prevalence, socio-demographical patterns and behavioral characteristics of LTPA. *Questionnaire*	*n* = 15,000 M: unknown F: unknown Age: 45–64 POLAND	Education: + Income: + Occupation: – Neighborhood: – Other: –	% of persons engaging in walking in their leisure time was highest in higher income groups. In the lower income SES groups, this proportion was significantly lower. 28.7 of respondents with higher education participated in moderate exercises, 18.2% with secondary education and 11.2% of those with primary or vocational education. 27.8% with the highest income performed moderate PA, but significantly lower for those with a lower income. Strong correlation between education and vigorous PA; those with higher education participated significantly more than those with lower education did. A similar correlation was observed for the income variable. Those of lower or medium SES engaged in vigorous exercises significantly less often than those with higher income [28]

Table 2. *Cont.*

Study	Aim and *Study Design*	Sample	Measures of SES [1]	Outcome/Conclusion
Borodulin et al., 2012	Explore associations of education and income with BMI and study the mediating pathways through health behavior. *Questionnaire*	*n* = 3258 M: 1555 F: 1703 Age: 25–75 FINLAND	Education: + Income: + Occupation: − Neighborhood: − Other: −	Significantly positive relationships found between education and LTPA and between income and LTPA for M and W [29]
Ord et al., 2013	Examine the extent to which green space is a venue for PA and if this could account for SES health inequalities in green neighborhood. *Survey*	*n* = 3679 M: 1621 F: 2058 Age: 16–75+ SCOTLAND	Education: − Income: + Occupation: − Neighborhood: − Other: −	An independent, positive association between household income and meeting the recommended walking guidelines and participation in green PA [30]
Uijtdewilligen et al., 2014	Examine the longitudinal of person-related factors with PA behavior in young adults. *Semi-structured interview*	*n* = 499 M: 248 F: 251 Age: 21–36 HOLLAND	Education: − Income: − Occupation: − Neighborhood: − Other: employment	M and W having no paid work spent significantly more time in Moderate PA than those working full time. Full-time working M spent significantly more time in vigorous PA than those without paid work. W: No association [31]
Marques et al., 2014	Identify correlated factors that explain the recommended level of LTPA among Portuguese adults. *Questionnaire*	*n*= 2166 M: 972 F: 1194 Age: 31–60 PORTUGAL	Education: + Income: − Occupation: + Neighborhood: − Other: −	For M, those with middle SES (OR = 1.47, 95% CI: 1.04–2.06, $p = 0.028$), high SES (OR = 1.88, 95% CI: 1.35–2.62, $p < 0.001$), had a higher and significant tendency for meeting PA recommendation in leisure time. For W, middle SES (OR = 1.40, 95% CI: 1.04–1.89, $p = 0.026$), middle level of education (OR = 1.41, 95% CI: 1.05–1.89, $p = 0.023$) were significantly associated with meeting PA recommendations during leisure time. For W, educational level was not significant when incorporated into the multivariate analysis [32]
Satariano et al., 2002	Examine the extent to which differences in LTPA are associated with differences in living arrangements. *Questionnaire*	*n* = 2073 M: 842 F: 1231 Age: 53–97 USA	Education: + Income: + Occupation: − Neighborhood: + Other: employed	Level of education was an important factor for both W and M. Those who engaged in higher levels of LTPA in both the full sample and among the married W were more likely to have had more than 12 years of education. Odds of participation were also elevated among W with more than 12 years of education. Engagement in highly vigorous PA compared to brisk PA also was elevated among W with more than 12 years of education (associations of LTPA and income/neighborhood are unknown) [19]
Huston et al., 2003	Examine associations between perceived neighborhood characteristics, access to places for PA, and LTPA. *Phone survey*	*n* = 1796 M: 680 F: 1116 Age: 18–65+ USA	Education: + Income: + Occupation: − Neighborhood: + Other: −	The % reporting any PA increased with increasing education level and with increasing income. The % engaging in recommended PA was higher in higher education groups and increased with increasing income. Although neighborhood characteristics were positively associated with engaging in any LTPA, these associations did not remain significant after adjusting for socio-demographic and other environmental factors. Neighborhood trails were also positively associated with engaging in PA, even after adjusting for socio-demographic and other environmental factors [33]
Ashe et al., 2008	Determine the proportion of elders who achieved a recommended amount of PA, and identify variables associated with meeting guidelines. *Telephone interview*	*n* = 24.233 M: 14,539 F: 9694 Age: 65–80 CANADA	Education: + Income: + Occupation: − Neighborhood: − Other: −	Higher proportions of people in the *No chronic disease* group met the PA guidelines if there was a higher level of education or income. Respondents in the highest income and education categories in the *Chronic disease* group attained the same proportion as the overall mean for the *No chronic disease* [34]

Table 2. *Cont.*

Study	Aim and *Study Design*	Sample	Measures of SES [1]	Outcome/Conclusion
Azagba & Sharaf, 2014	Examine LTPIA and its correlates among older Canadian adults. *Questionnaire*	*n* = 45,265 M: 22,814 F: 22,451 Age: 50–79 CANADA	Education: + Income: + Occupation: − Neighborhood: − Other: −	Significant association with being PIA. Education: postsecondary (OR = 0.62, CI = 0.57–0.68), some postsecondary (OR = 0.68, CI = 0.58–0.80) and secondary (OR = 0.81, CI = 0.73–0.91) are less likely to be PIA relative to those with less than secondary education. Income: only the high and low middle-income categories are significantly different from low income. Those in the high-income category are less likely to be PIA than the low-income category (OR = 0.90, CI = 0.81–1.00) [35]
Dias-da-Costa et al., 2005	Measure the prevalence of PIA during leisure time, and identify variables associated. *Questionnaire*	*n* = 1968 M: 846 F: 1122 Age: 20–69 BRAZIL	Education: + Income: + Occupation: − Neighborhood: − Other: household	Schooling and economic level were inversely related to low LTPA [36]
Azevedo et al., 2007	Explore the association between gender and LTPA, and study a variety of variations associated with PA. *Questionnaire*	*n* = 3100 M: 1344 F: 1756 Age: 20–70 BRAZIL	Education: + Income: − Occupation: − Neighborhood: − Other: economic level	M with high education presented 75% lower risk of scoring zero in comparison to those with low education. Among W, this difference was 35%. Economic level showed a clear dose-response positive association with the PA score among W. Those in the least wealthy group ('E') presented 110% increased prevalence of score zero in comparison with those from level "A". Among M, groups "C", "D" and "E" presented comparable prevalence of subjects scoring zero, approximately 60% higher than M from the "A" level [37]
Reis et al., 2013	Examine the association between walkability and PA outcomes, and the effect of income on the relation between walkability and PA in adults. *Questionnaire*	*n* = 697 M: 334 F: 363 Age: 18–65 BRAZIL	Education: − Income: + Occupation: − Neighborhood: + Other: numbers of cars, children	No interactions between walkability and income were found. Leisure- time moderate-to-vigorous PA ranged 12.2–19.3% in low income areas, and 25.3–35.8% in high-income areas. Neighborhood income was independently associated with leisure- time moderate-to-vigorous PA (OR = 1.70, 95% CI = 1.06, 2.74, p = 0.029) [38]
Brown & Siahpush, 2006	Investigate predictors of being sedentary. *National Health Survey*	*n* = 16,243 M: 7600 F: 8643 Age: 18–60+ AUSTRALIA	Education: + Income: + Occupation: + Neighborhood: Index of relative SES	Low education level, blue-collar occupation, low income, and area social disadvantage were all significant predictors of sedentary behavior. Significant relationships between all SES variables and PA levels in both M and W. All indicators of low SES are powerful individual contributors to being sedentary [39]
Cerin et al., 2008	Identify individual, social, and environmental contributors to individual- and area-level differences in LTPA across SES. *Questionnaire*	*n* = 2194 M: 790 F: 1404 Age: 20–65 AUSTRALIA	Education: + Income: + Occupation: − Neighborhood: + Other: employment status, household	Respondents with a medium household income had 12.9%, and those with a high household income had 23.5% higher mean values of walking for recreation than respondents with a low household income. Compared to the SES reference categories, individuals with a secondary education, with medium household income, and living in a medium-income neighborhood would report 33.5% more recreational walking due to differences in the examined mediating variables. The mediated difference in mean walking between the lowest and highest SES categories was 53.9% [40]

Table 2. *Cont.*

Study	Aim and *Study Design*	Sample	Measures of SES [1]	Outcome/Conclusion
Gearon et al., 2013	Ascertain the contribution of specific dietary elements and LTPA to variations in obesity with education. *Questionnaire*	*n* = 30,630 M: 12,141 F: 18,489 Age: mean 55 AUSTRALIA	Education: + Income: − Occupation: − Neighborhood: − Other: −	Those with lower educational attainment appeared less likely to engage in high levels of LTPA for both M and W [41]
Mabry et al., 2012	Identify sociodemographic, anthropometric, and behavioral correlations of occupational, transport and leisure-time inactivity (OPIA, TPIA and LTPIA), and sitting time among adults in Oman. *Questionnaire*	*n* = 1335 M: 591 F: 744 Age: mean 36.3 OMAN	Education: + Income: − Occupation: − Neighborhood: − Other: work status	M: no significant association with OPIA or TPIA. Significantly higher odds of LTPIA for lower education ($p = 0.03$), and for not employed vs. employed ($p < 0.05$). F: no significant association with OPIA or TPIA. OR of LTPIA were 1.8 higher for not employed [42]
Adeniyi & Chedi, 2010	Explore the SES and demographic predictors of PA in pre-retired and retired in Nigeria. *Questionnaire*	*n* = 532 M: Unknown F: Unknown Age: 28–68 NIGERIA	Education: + Income: + Occupation: − Neighborhood: − Other: job duration	For both the retired and pre-retirement civil servants (. . .) current monthly income and job duration significantly predicted their engagement in mod PA. The lowest income group and the respondents with shortest job duration had significantly lower engagement than the higher SES groups [43]

[1] The symbols +/− indicates whether the particular SES measure is used in the study (+) or not (−).

Table 3. Studies investigating PA in adults across SES. Negative relationships.

Study	Aim and *Study Design*	Sample	Measures of SES [1]	Outcome/Conclusion
Van Dyck et al., 2010	Investigate whether neighborhood walkability is positively associated with PA and whether this association is moderated by neighborhood SES. *Questionnaire + accelerometer*	*n* = 1166 M: 558 F: 607 Age: 20–65 BELGIUM	Education: − Income: − Occupation: − Neighborhood: annual household Other: −	Living in a high-SES neighborhood was associated with significantly less walking for transport and more motorized transport. The accelerometer measured less activity (min/day) in the high SES neighborhood [20]
Guessous et al, 2014	Examine the association of cardiovascular risk factors, biomarkers, and SES factors with PA. *Questionnaire*	*n* = 9320 M: 4619 F: 4659 Age: 35–74 SWITZER-LAND	Education: + Income: + Occupation: + Neighborhood: − Other: −	High education level subjects had lower activity than subjects with low education had. Compared to the category of non-manual, managerial or independent labor, all other categories had higher 3+ MET-minutes per week, especially those with manual labor occupations [44]

Table 3. *Cont.*

Study	Aim and *Study Design*	Sample	Measures of SES [1]	Outcome/Conclusion
Wolin et al., 2008	Explore potential variation in the OPA–LTPA relation across gender and socioeconomic position strata. *Survey*	*n* = 5448 M: 2550 F: 2898 Age: 18–70 USA	Education: + Income: − Occupation: − Neighborhood: − Other: −	There was no association between education and LTPA. The association remained non-significant after adjusting for covariates and in gender-stratified multivariable models. Significant inversely association between education and OPA [45]
Hearst et al., 2013	Investigate the relationships between neighborhood-level sociodemographic context, individual level sociodemographic characteristics and walking for leisure and transport. *Questionnaire*	*n* = 550 M: 118 F: 432 Age: 26–70 USA	Education: + Income: − Occupation: − Neighborhood: + Other: free lunch	Those w/least resources did most walking overall. Those from the highest two levels of resources or least disadvantaged neighborhoods had fewer minutes of TPA walk as compared to those coming from the least resourced or most disadvantaged neighborhoods. There were no differences in LTPA walk by neighborhood characteristics. There was no significant difference in walking by education level although there was a trend for less LTPA walking for individuals reporting at least a college education. Finally, those respondents who did not report qualifying for free or reduced lunch had fewer minutes of TPA walking as compared with those that did qualify for free/reduced lunch [46]
Kienteka et al., 2014	Analyze the association between personal and behavioral aspects in TPA bicycling and LTPA bicycling in adults. *Questionnaire*	*n* = 677 M: 317 F: 360 Age: 18–65 BRAZIL	Education: + Income: − Occupation: − Neighborhood: − Other: work status, assets	After adjusting for all confounding variables, those of low SES (PR = 5.00; 95%CI: 1.65–15.17; p = 0.006), reported using a bicycle for TPA more frequently [47]
Fogelman et al., 2004	Investigate the accuracy of self-perception of participation in PA, and the correlations of PA with background factors. *Questionnaire*	*n* = 276 M: Unknown F: Unknown Age: 20–65 ISRAEL	Education: + Income: + Occupation: − Neighborhood: − Other: −	Subjects with fewer years of education engaged in more OPA, however, the differences did not reach strong significance. Other correlations between PA indices and predictive SES-variables were not significant [15]
Trinh et al., 2008	Identify PA patterns and factors associated with "insufficient" levels of PA for health in adults. *Questionnaire*	*n* = 1906 M: 884 F: 1022 Age: 25–64 VIETNAM	Education: + Income: + Occupation: + Neighborhood: + Other: household	Income and household wealth index significantly related to insufficient PA. Monthly income associated with insufficient PA. However, the household wealth index shows a significant association from the middle quintiles onwards, with people from wealthier households having greater risks of insufficient PA; especially among M. Tests for trend across income and household wealth index also confirmed this observation. The results across both genders show this association, but no significant association in W [48]
Naseer et al., 2013	Identify sex-based differences in the perception of benefits and barriers toward exercise and determine the sex- and age-based differences in the level of PA in adult residents of Karachi. *Questionnaire*	*n*= 300 M: 125 F: 175 Age: 18< PAKISTAN	Education: + Income: + Occupation: − Neighborhood: − Other: work status	PA was highest in M w/income less than 6000 Pakistan rupees. PA is lowest in M w/income between 6000–16,000 Pakistan rupees. F: less fluctuation in results. Education not reported [49]
Vaidya & Krettek, 2014	Measure PA in LTPA, OPA + TPA in a peri-urban community and assess its variations across different sociodemographic correlates. *Questionnaire*	*n* = 640 M: 175 F: 465 Age: 25–59 NEPAL	Education: + Income: − Occupation: + Neighborhood: − Other: −	Low PA was lowest among males who had studied up to grade 4 (23.3%). Compared with informal education, PIA was ×3 higher in individuals educated up to high school or more. Those who worked in agro-based jobs had the highest Total PA. In terms of Total PA, inadequate PA was more likely in government employees, self-employed individuals, and housewives [50]

[1] The symbols +/− indicates whether the particular SES measure is used in the study (+) or not (−).

Table 4. Studies investigating PA in adults across SES. No relationship.

Study	Aim and *Study Design*	Sample	Measures of SES [1]	Outcome/Conclusion
Schneider et al., 2009	Group clusters that exhibit specific health behavior patterns regarding (. . .) and PA. *Phone interview (questionnaire)*	*n* = 2002 M: 982 F: 1020 Age: 50–70 GERMANY	Education: + Income: + Occupation: + Neighborhood: − Other: −	No significant characteristic of the inactive cluster related to SES [51]
Molina-García et al., 2010	Examine psychosocial and environmental correlations of TPA to university and explore its associations with overall PA among students. *Survey*	*n* = 518 M: unknown F: unknown Age: 22.4 SPAIN	Education: − Income: − Occupation: − Neighborhood: − Other: (low→high)	SES was not a significant correlate of active commuting to university [17]
Chen et al., 2011	Explore the determinants influencing adults' LTPA in a city in southern Taiwan. *Questionnaire*	*n* = 762 M: 359 F: 403 Age: 40–67 TAIWAN	Education: + Income: − Occupation: + Neighborhood: − Other: marital status	Indicators of high SES were positively associated with participation in exercise/sports, but no significant correlation was found [52]

[1] The symbols +/− indicates whether the particular SES measure is used in the study (+) or not (−).

Table 5. Studies investigating PA in adults across SES. Mixed relationships.

Study	Aim and *Study Design*	Sample	Measures of SES [1]	Outcome/Conclusion
Borrell et al., 2000	Describe social class inequalities in health related behaviors. *Interview survey*	*n* = 4171 M: 1942 F: 2229 Age: 14–65+ SPAIN	Education: − Income: − Occupation: + Neighborhood: − Other: −	Less than 5% of M and W in class 1 (highest SES) declared that they usually performed intense PA in contrast with 11.5% of M and 8.6% of W in class 5, an association that persisted in the multivariate analysis. People of classes 1&2 were more likely to engage in usual PA classified as "light or none" than lower classes. For LTPA the situation was reversed, particularly in M, as a greater proportion of the lower classes did not engage in PA three or more times per week. In the multivariate analysis, the association was not significant. In W, there was no clear trend. Engaging in usual PA as "light or none" in M decreased with lowering class [53]
Livingstone et al., 2001	Evaluate habitual levels of PA. *Questionnaire*	*n* = 1369 M: 655 F: 714 Age: 18–64 IRELAND	Education: − Income: − Occupation: + Neighborhood: − Other: −	Professional/skilled non-manual M engage in less total and OPA than M from other social groups. Reverse in W. HPA by M were broadly similar across social class groupings but W in skilled manual/partly skilled/unskilled occupations spent more time in these HPA than W from other social groups. Differences in time spent in vigorous active recreation by M were reported, but none was significant. Approximately 2× difference in the range of time spent in vigorous active recreation by the W (0.7 ± 0.9 h·week^{-1} skilled manual vs. 1.2 ± 2.0 h·week^{-1} skilled non-manual). W in professional/skilled non-manual groups spent significantly more time in these pursuits than W in other social class groupings [54]

Table 5. *Cont.*

Study	Aim and *Study Design*	Sample	Measures of SES [1]	Outcome/Conclusion
Popham & Mitchell, 2007	Investigate further associations between SES position and overall PA levels and specific types of PA. To investigate the role of employment status and health. *Questionnaire*	*n* = 5287 M: 2346 F: 2941 Age: 25–64 SCOTLAND	Education: + Income: − Occupation: + (parent's and own) Neighborhood: − Other: housing tenure	Increasing accumulated socioeconomic disadvantage was associated with higher rates of low or no PA. For M, this association largely disappeared after adjustment for employment status and health, while among W the differences were reduced. Although low SES was associated with higher rates of OPA, the most disadvantaged did not have the highest rate. However, after adjustment for employment status (especially) and health, a clearer social gradient in OPA emerged in which relative rates of OPA increased with increasing disadvantage. Low SES was associated with low rates of participation in brisk walking, sport and exercise and heavy manual leisure. SES differences in these PA were not greatly changed after adjustment for health and employment status [55]
Allender et al., 2008	Examine relative contribution of OPA to English adults' meeting PA recommendations. *Cross-sectional survey, individual interviews*	*n* = 13,974 M: 6237 F: 7737 Age: 16–75+ ENGLAND	Education: + Income: + Occupation: + Neighborhood: − Other: −	Education: OPA included, M w/any qualification were more likely to meet the PA guideline than those w/a degree or higher or the no qualification group. OPA removed; those w/any qualification or a degree qualification or higher were more likely to meet the guideline than the no qualifications group. Occupation: OPA included; unskilled manual, semiskilled manual and skilled manual W were more likely to meet the PA guideline than the professional group. Not significant when OPA was removed from the analysis [56]
Jurakic et al., 2009	Determine the PA level in different domains of everyday life. *Questionnaire*	*n* = 1032 M: 500 F: 532 Age: 15+ CROATIA	Education: + Income: + Occupation: − Neighborhood: − Other: settlement	Total PA was inversely related to the size of settlements. OPA domain was also inversely related to the size of settlements. Furthermore, TPA was inversely related to household income, while PA in HPA was positively related to age and inversely related to the size of settlements and educational level. Finally, LTPA was positively related to the size of settlements and to household income [57]
Molina-García et al., 2014	Describe differences in energy exposure in active commuting to university by transport mode in students and examine sociodemographic associations with energy exposure. *Questionnaire*	*n* = 518 M: 209 F: 309 Age: mean 22.4 SPAIN	Education: − Income: − Occupation: − Neighborhood: − Other: subjective definition	Low SES-students walked more but biking was significantly higher in the high SES group than the medium SES group [18]
Golubic et al., 2014	Describe PA and sedentary behavior and examine the variation of PA-sub-components by key health-related, anthropometric, and socio-demographic factors as well as prior PA. *Questionnaire, heart rate and move sensing*	*n* = 1787 M: 862 F: 925 Age: 60–64 GREAT BRITAIN	Education: + Income: − Occupation: + Neighborhood: − Other: employment status	For those still working, M in manual work had higher PA energy expenditure (14%), than non-manual workers, but values for W did not differ. In W, PA energy expenditure were greater with higher education. PA energy expenditure from questionnaire was higher in full-time employed than in those who were employed part time or retired. PA energy expenditure were greater in those in manual than non-manual occupations in M, but not significant in W. W with higher education had higher PA energy expenditure than those with lower, but the opposite patterns were observed in M [21]
Hawkins et al., 2004	Describe the prevalence of self-reported moderate/vigorous PA. *Questionnaire*	*n* = 40,261 M: 18,375 F: 21,406 Age: 20–55+ USA	Education: + Income: − Occupation: − Neighborhood: − Other: −	Subjects with education beyond high school were less likely to meet the moderate PA guideline than those with less education. The younger, M, and better educated were most likely to achieve the vigorous PA guideline before and after adjustment for potential confounding variables [58]

Table 5. *Cont.*

Study	Aim and *Study Design*	Sample	Measures of SES [1]	Outcome/Conclusion
Berrigan et al., 2006	Explore inclusion of *non-leisure-time walking and bicycling* (NLTWB) used for transportation on the prevalence of adherence to PA recommendations and the magnitude of apparent disparities in adherence for Californian adults. *Phone survey*	*n* = 55,151 M: 22,930 F: 32,221 Age: 18–≥70 USA	Education: + Income: + Occupation: − Neighborhood: − Other: −	Adherence based on LTPA increased with education and income level. By contrast, adherence based on NLTWB decreased with education and income. Logistic regression confirmed the presence of significant effects of(. . .) education, and income on adherence based on LTPA and the prevalence of adherence based on LTPA and NLTWB combined. In multivariate models, (. . .) education, and income, were associated with adherence based on NLTWB alone. LTPA increases as education and income levels increase but NLTWB decreases [16]
Lee & Levy, 2011	Examine PA in multiple contexts and blood pressure across gender and income among older adults living independently. *Questionnaire*	*n*= 372 M: 128 F: 244 Age: 60+ USA	Education: + Income: + Occupation: − Neighborhood: − Other: −	M at low income levels reported greater HPA than M at high income levels. For W, no differences by income level in HPA were seen. Income level alone also made a significant contribution to differences seen in HPA however these effects appear to have been overridden by the significant interaction. Income level significantly contributed to differences seen in total LTPA with those at low income levels reporting less LTPA than those with higher income levels [59]
Florindo et al., 2009	Estimate the prevalence of and identify factors associated with LTPA, TPA, OPA and HPA. *Questionnaire*	*n* = 1318 M: 652 F: 666 Age: 18–65 BRAZIL	Education: + Income: − Occupation: − Neighborhood: − Other: −	Higher education level was negatively associated with low level of LTPA, while it was positively associated with low activity in both OPA and HPA [60]
Bicalho et al., 2010	Estimate the PA level and its association with SES factors in adults living in rural areas. *Questionnaire*	*n* = 567 M: 275 F: 292 Age:18–60 BRAZIL	Education: + Income: − Occupation: − Neighborhood: − Other: marital status	There was an inverse relationship between education and the percentage of participants performing 150 min. at work. Education had an inverted U-shaped association with the practice of HPA, in the total population and in W. M (p = 0.133). LTPA was more frequent in individuals with greater education for total, M, and W. M with higher education were the least active in the TPA domain. (W and total: not significant) [61]
Del Duca et al., 2013	Estimate the prevalence and sociodemographic indicators associated with PIA LTPA, TPA, OPA and HPA in adults. *Questionnaire*	*n* = 1720 M: 769 F: 951 Age: 20–59 BRAZIL	Education: + Income: + Occupation: − Neighborhood: − Other: −	LTPA: those with lower education and lower income had higher probability of PIA. TPA: higher income presented higher prevalence of PIA. OPA: higher education and income, more PIA. HPA: Higher education and higher income; higher prevalence of PIA [62]
Linetzky et al., 2013	Evaluate how SES gradients in non-communicable diseases and non-communicable disease-related risk factors change over time (2005–2009). *Questionnaire*	*n* = 41,392/34,732 M:17,827/15,028 F:23,565/19,704 Age: 43.3/43.6 ARGENTINE	Education: + Income: + Occupation: − Neighborhood: − Other: −	In 2005, M with low education (OR = 0.65, 95% CI = 0.50–0.85) and medium education (OR = 0.79, 95% CI = 0.67–0.93) were less likely than males with high education to be physically inactive. In 2009, the direction of the gradient switched direction. By 2009, W with low education (OR = 1.57, 95% CI = 1.34–1.84) and medium education (OR = 1.18, 95% CI = 1.06–1.32) were more likely than women with high education to be physically inactive [63]

Table 5. *Cont.*

Study	Aim and *Study Design*	Sample	Measures of SES [1]	Outcome/Conclusion
Giles-Corti et al., 2002	Examine spatial access to recreational facilities and perceptions of the neighborhood environment and PA levels by the SES of area of residence. *Survey*	*n* = 1803 M: 580 F: 1223 Age: 18–59 AUSTRALIA	Education: + Income: + Occupation: − Neighborhood: + Other: work outside home, access to motor vehicle	No difference between the two SES areas in walking overall, but the types of walking differed significantly. Compared with high SES areas, walking for transport was 33% more prevalent in walkers from low SES areas and walking for recreation was 21% lower. Participation in vigorous PA was 24% lower for those living in low SES areas compared with those in high SES areas and participation in light to moderate PA was 16% lower. On average, compared with those living in high SES areas, those living in low SES areas who walked for transport did so for nearly 1 more hour per fortnight more. Although the difference in walking occasions did not reach significance, in low SES areas transport walkers walked on nearly two more occasions per fortnight. Respondents living in low SES areas were 26% less likely to do sufficient PA compared w/those living in high SES areas. The odds of reaching high levels of vigorous PA were also near 50% lower [64]
Proper et al., 2006	Examine the influence of neighborhood and individual SES on OPA. *Questionnaire*	*n* = 1236 M: 470 F: 766 Age: 20–65 AUSTRALIA	Education: + Income: + Occupation: − Neighborhood: + Other: −	Neighborhood SES and individual SES were independently inversely related to absolute and relative amount of OPA. Significant interactions between neighborhood SES and level of educational attainment in the contribution of total and vigorous OPA to total PA were found [65]
Kahan, et al., 2005	Evaluate levels of LTPA, OPA, sports PA and correlate them with SES and health factors *Questionnaire*	*n* = 406 M: 173 F: 211 Age: 20–65 ISRAEL	Education: + Income: + Occupation: − Neighborhood: − Other: −	OPA level decreased with level of education, whereas sports PA increased. The sports index was also directly correlated with monthly income status: income 5000< NIS (4 NIS equaled U.S. $1.00) was associated with a significantly higher sports PA index and lower OPA index. Regression models showed that the lower the level of education, the greater the degree of OPA and the lower the degree of sports PA. The higher the income, the greater tendency to less OPA but more at sports PA [66]
Khaing Nang et al., 2010	Evaluate the characteristics of individuals participating in different PA domains. *Questionnaire*	*n* = 4750 M: 2280 F: 2470 Age: 18–60 SINGAPORE	Education: + Income: + Occupation: − Neighborhood: − Other: work, house	A higher SES was associated with a higher likelihood of participating in LTPA. OPA was higher in those with low SES. TPA was lower for those with higher SES. HPA was lowest for those with higher SES. Participants with a higher SES had more LTPA, but less OPA, TPA and HPA resulting in lower overall PA [67]
Saito et al., 2013	Examine the association of 3 types of PA and their associations with individual and neighborhood environmental factors among middle-aged and elderly Japanese. *Questionnaire*	*n* = 1940 M: 943 F: 997 Age: 40–69 JAPAN	Education: + Income: + Occupation: − Neighborhood: + Other: employment, number of children	Not working increased and number of children in the household decreased the odds of all three types of PA (not all significant). Economic status increased the odds of moderate-to-vigorous LTPA but decreased the odds of transport-related walking. High education increased the odds of moderate-to-vigorous LTPA. Owing motor vehicles increased the odds of engaging in moderate-to-vigorous LTPA other than walking [68]
Talaei et al., 2013	Investigate PA by SES and sex in an Iranian adult population. *Questionnaire*	*n* = 6622 M: 3221 F: 3401 Age: mean 45.2 IRAN	Education: + Income: + Occupation: + Neighborhood: − Other: employment	LTPA: higher for high SES participants than middle and low SES for both M and W. OPA: W: no significant difference between low and high SES. M: less in high than middle and low SES. HPA: W: significantly different ($p < 0.001$) higher in middle than high and low SES: it was lower in high than low SES. M: No significant differences found. TPA: M and W: No significant differences [69]
Ying Chan et al., 2014	Examine the association between socio-demographic factors and PIA by gender. *Questionnaire*	*n* = 33,949 M: 15,205 F: 18,744 Age: 18–65+ MALAYSIA	Education: + Income: + Occupation: − Neighborhood: − Other: employment	PIA in M increased with increasing income, but not in W. The widow/widower/divorcee, non-working group, and those with no formal education were found to have high PIA in both M and W [70]

PA: physical activity; LTPA: leisure time physical activity; OPA: occupational physical activity; HPA: household physical activity; TPA: transporting physical activity; PIA: physical inactivity; SES: socioeconomic status; SEP: Socioeconomic position; M: men; W: women. [1] The symbols +/− indicates whether the particular SES measure is used in the study (+) or not (−).

3.1. Directions of Relationships: Geographical Region, Period of Publication, SES Measure and Age

Of all 56 studies in the sample, fewer than half (23) reported a predominantly positive relationship between PA and SES. Nine studies reported a primarily negative relationship (low SES more active), whereas three studies showed no relationship at all. The remaining 21 studies reported mixed results.

Only one of the 11 Asian studies [42] reported a positive relationship between PA and SES (i.e., greater likelihood of PIA in lower-SES groups), whereas approximately half of the studies from all other continents demonstrated positive relationships.

Over time, although the proportion of studies showing positive results remained constant, the group of studies showing mixed results diminished at the expense of studies showing negative or no relationships.

The results of our analysis provide no evidence that the choice of SES variable affects the direction of the relationship between PA and SES in adults. No marked differences emerged in the use of SES measure by continental affiliation, either.

Using the mid-range of the individual age range in each sample, except when mean age was the age-related information given, we calculated the arithmetic mean, mode and median of age in each group of studies categorized according to the direction of relationship between PA and SES (Three studies were excluded from these calculations due to limited information on age (i.e., lowest age only)). The group of studies demonstrating positive relationships had a slightly higher mean, mode, and median age (i.e., 48.5, 45 and 45 years, respectively) than the other groups. Conversely, the group of studies demonstrating mixed relationships between PA and SES had the lowest mean, mode, and median age (i.e., 41.6, 40 and 40 years, respectively).

3.2. Physical Activity Domains

All studies included in the present review presented data on the type or mode of PA, sometimes referred as "PA domains" (i.e., LTPA, OPA, TPA and HPA), according to which they were categorized. For most studies in which the term "domain" was not used, it was still possible to assign the type of PA to a domain. Sports, exercise and walking for recreation were classified as LTPA, for example, whereas gardening was classified as HPA. By enumerating the frequency at which the different domains were studied, a preponderance of LTPA was observed either alone or in combination with other domains. Studies had examined OPA and TPA equally often, albeit far less than LTPA (see Figure 1 for details).

Categorizing the studies revealed a clear tendency of a positive relationship between PA and SES in the LTPA domain but not necessarily in other domains. In 22 of the 32 studies addressing LTPA [16,19,24,25,28–30,33,38,40,41,43,55,57,59–61,64,66–69], a positive relationship with SES was found, whereas a negative relationship was found in only one study [44]. The remaining nine studies [21,32,45,46,51–54,58] reported less clear answers due to differences dependent upon gender, SES-measure, or other confounding effects. Nine of the 11 studies that included the OPA domain demonstrated negative relationships between PA and SES [15,45,55,57,60,61,65–67] whereas none of the studies including the OPA domain demonstrated a positive relationship between OPA and SES. In two studies [55,70], results were mixed due to differences across gender. Studies that included the TPA domain seemed to similarly demonstrate negative results; nine such studies [16,20,46,47,57,61,64,67,68] demonstrated negative relations, whereas three demonstrated non-existent or negative relationships [17,18,69], if not both. Of the eight studies examining HPA and SES, none demonstrated a positive relationship, although four demonstrated negative relationships [57,60,67,69], and four others demonstrated non-existent or mixed relationships related to gender differences [25,54,59,61], as illustrated in Figure 1.

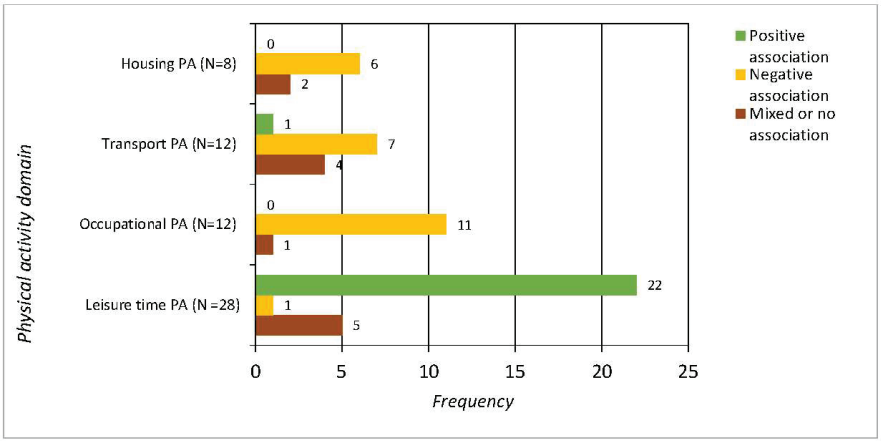

Figure 1. Results demonstrating positive, negative, mixed or no association between SES and PA within PA domains. Occasions, in which a domain has been studied (some studies include more than one domain). Seventeen studies reporting either PIA or total PA level without separating different PA domains are not included in this figure.

3.3. Effects of Gender

An analysis of a subgroup of 26 studies reporting gender-specific results revealed that the relationship between SES and PA was positive for both men and women in the LTPA domain. The mentioned relationship between SES and OPA remained negative for men (low SES more active) but might have been somewhat less established in women. For the remainder of the domains (i.e., TPA and HPA), no clear trend was evident across the studies.

4. Discussion

In the present review, only 23 of the 56 studies (41%) found that individuals of higher SES were more physically active than their low-SES counterparts, whereas nine studies reported the opposite (individuals of lower SES were more physically active). For 24 studies (43%), resolution is still wanting, in that they report either no effect of SES on PA or mixed effects with some variables favoring high SES and others falling on the side of the lower-SES population.

When the results were organized by PA domains, a very clear picture emerged. Out the 32 studies that reported LTPA, 22 concluded that individuals with higher SES were more active, whereas that relationship appeared only once in the 33 studies when other PA domains examined (Figure 1). Regarding the other domains (i.e., HPA, TPA and OPA), an inverse relationship appeared for as many as two-thirds of studies, indicating that individuals from lower-SES groups were more physically active. In nine studies, no relationship was found between PA and SES.

Furthermore, when results were organized according to the respective domains, a few important nuances surfaced. LTPA was positively related to SES irrespective of gender, whereas the OPA-SES relationship was positive for males and negative for females. The other relationships (i.e., TPA-SES and HPA-SES) remained unclear, however.

Our results show, as with Stalsberg and Pedersen [5], Gidlow et al. [3] and Beenackers et al. [4] before, that the relationship between PA and SES is not as clear-cut as assumed. More importantly, the results support Beenackers et al.'s [4] findings that the relationship between PA and SES depends upon which PA-domains are measured. Thus, our findings upheld our hypothesis. At the same time, although we had limited data from developing countries, our results seem to support Palma and Assis' [9] argument that studies' undue focus on LTPA would misrepresent PA levels among

populations in such countries. To that argument, we can add that the same would apply to the low-SES population of developed countries. Furthermore, the focus on PA in interventions, although certainly warranted, has obscured other variables not under the control of individuals. For example, the PA level of individuals of low SES likely suffers from their living in areas with less access to parks [71], or with less neighborhood walkability [72] and their health is also negatively affected by the cost of healthy food compared to that of junk food [73].

What the present results may indicate is that although individuals of lower SES have fewer financial resources to engage in leisure activities, they are more physically active than has been assumed when other PA domains (e.g., OPA and TPA) are taken into consideration. In, for example, Del Duca et al. [10] mentioned earlier, many individuals who were otherwise categorized as inactive, in fact, met recommendations for PA when data on TPA were included as opposed to when only LTPA was counted. It is reasonable to assume that people of lower SES have less surplus energy to be physically active during their leisure time, because of the physical strain of their work [74]. Moreover, there is reason to believe that people of higher SES are more active in their leisure time, out of necessity, because they are less physically active at work [67], and not merely because of their ability to finance their activities.

The various operationalizations of the SES variable in previous studies have complicated comparisons across studies (see Gidlow et al. [3], and Stalsberg and Pedersen [5] for some more detail). In the present review, as education was the predominant variable for establishing SES among included studies, and the PA variable was held more stringent by the inclusion criteria, thus it secured a more homogenous batch of studies, the picture becomes clearer. The previously touted relationship between SES and PA is mainly a relationship between higher education and LTPA.

Our results also suggest that studies on PA, including those investigating relationships with SES, have largely focused on LTPA, often in the form of registered sports participation, membership in sport clubs, and the like. That trend was apparent in all but five studies in our sample, and in 15 studies, LTPA was the sole variable. Studies of OPA, TPA and HPA remain scarce and have often been hampered with methodological inadequacies that blur the results. The reason for such bias could be that the four dimensions of PA (mentioned earlier) are easier to report in sports and other forms of LTPA and, even that the PA-questionnaires predominantly used are better adjusted for reporting such activities.

The mentioned methodological consequences of over-generalizing results of LTPA-oriented studies could partly explain many of the observed differences in our dataset. For example, among Asian studies, only one of 11 studies [42] demonstrated positive relationships between PA and SES (higher SES were less inactive) compared with approximately half of the studies from all other continents combined. Such a finding suggests either that the relationship between the SES and PA differs for Asians compared with the rest of the world or, more likely, that the European and American studies have placed undue focus on LTPA compared with other domains.

In studies that reported less clear or even negative relationships, observed gender-based differences also arguably coincide with the reality that women less often than men engage in sports [75], more often than men engage in household activities [76] and have less physically demanding occupations [77,78] than men do. Thus, no relationship emerged between PA and SES for females in our results.

The trend, albeit unclear, that studies including older participants more often demonstrate positive relationships between SES and PA could relate to the fact that older individuals have more leisure time than younger ones. Furthermore, when studies have included groups of retirees, they have run the risk of underreporting OPA as well as TPA to and from work that would otherwise shift total PA in the direction of the low-SES group.

The change in the relationship over time, also unclear, that more recent studies more often have demonstrated negative relationships could partly derive from the fact that those studies, compared with previous ones, included other PA domains instead of focusing solely on LTPA. Moreover, the trend

of studies being more geographically diverse in recent years might have served to shift the focus away from LTPA.

When measuring LTPA, and drawing conclusions about PA as a result, low-SES groups have appeared to be less physically active than they are, whereas the PA levels of high-SES groups have been overestimated. In addition, as Palma and Assis [9] have underscored, developing countries are misrepresented as having less physically active populations than developed countries because the former have far more physically demanding, time-consuming work that leaves less time for leisure activities, both due to less leisure time and greater fatigue after work, hence their reduced inclination to engage in PA.

Another factor could be that studies of PA and SES are typically designed and conducted by individuals who belong to high-SES groups (e.g., researchers and physicians), which are characterized by their higher education, higher income, and less physically demanding occupations [79]. A social group holding the power to define and value or rate a social phenomenon might have the misfortune to disregard their own preconceptions and introduce bias as a result.

Recent studies have argued that sedentary time might be a better indicator of health risk than lack of PA is [80,81]. Furthermore, it has been suggested that not even increased levels of physical exercise, sometimes mistaken for increased levels of total PA, can compensate for the declining levels of everyday PA, tentatively termed "daily life physical activity" (DLPA) by Stalsberg and Pedersen [11]) (cf. [82,83]). The over-eager focus on LTPA in scientific studies might have masked the lack of DLPA and thus prompted the underestimation of public health risks.

When studying PA to be able to offer health advice, researchers should remember that the level of PA is but one of several variables that determine an individual's health. As a case in point, Beckvid Henriksson et al. [11], found that the most physically active group – in their case, the low SES group—was also the one with the poorest health. In response, those authors suggested differences in diet across groups as another variable relevant to explaining their findings (see also [84]).

The present study clearly involved limitations. Above all, our results cannot falsify the claim that individuals of higher SES are more active, which was not our aim in the first place. Furthermore, our results do not support conclusions about the total PA levels of any SES-group, since most studies do not report all PA-domains. Even if individuals of low SES are more physically active than they have been credited to be, we do not know whether that trend would contribute positively to their health, for all PA is not necessarily equally healthy. In fact, much of their work PA, might even be harmful. Last, we did not include data on sedentary time for any of the groups, which makes it impossible to draw conclusions about any health-related issues, as they depend upon both total PA and accumulated sedentary time.

What our results contribute, however, is that the findings of studies seem to have varied across PA-domains and that the entire field of research on PA seems to have given undue attention to LTPA. Thus, results might become less clear when other domains are added to the mix. That possibility indicates directions for future studies seeking to respond to the questions that remain unanswered. More practically, researchers should report all PA-domains and account for sedentary time so that the variables can be balanced against each other.

5. Conclusions

The assumed relationship between PA and SES is mostly a relationship between LTPA and high SES. No such relationship or a negative relationship between PA and SES for all other PA domains exists, which indicates that individuals from low-SES groups are more active. Whether the high- or low-SES group is more physically active in total remains unclear and is difficult to determine with any certainty based on available data. In any case, no comparison of PA across SES groups should be made without accounting for not only total LTPA, as is currently common, but also total PA. Developing countries and the low-SES group might also have been misrepresented in studies on PA. Those populations might be more physically active than they have been credited to be, the misconception of which is due

perhaps to the fact that researchers most often come from high-SES populations in developed countries. That finding has consequences for practitioners targeting low-SES populations with interventions that attempt to increase their PA levels, and we suggest that researchers and practitioners should look beyond the mere amount of PA for other variables that can explain health-related differences across SES groups.

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Original article

Physical activity in long-term breast cancer survivors – A mixed-methods approach

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ABSTRACT

Objectives: Traditional methods measuring physical activity (PA) may misrepresent breast cancer survivors (BCSs) and low-socioeconomic status (SES) groups. This study identifies PA-levels, routines and experiences among BCSs, in general and by SES, and explores whether a mixed-methods approach might unveil diversities of PA in BCS across SES.
Materials and methods: 250 BCSs referred to postoperative radiation therapy in 2007–2008 participated in a longitudinal follow-up study examining health-related quality-of-life and late-effects. Subsample-data on SES and PA were collected by questionnaires (n = 52), activity-logs (n = 52) and interviews (n = 37). Parallel mixed analyses were conducted, in combination with sequential, full-sample analyses of questionnaires and contrasting case analyses of logs and interviews.
Results: Dependent on which measurement used, 23%, 35%, 54% and 63% of BCSs met PA guidelines. Questionnaire-data revealed no significant differences in PA levels between SES groups. Log-data showed more PA bouts in high-SES BCSs, but no difference in min/week across SES. Neighbourhood walking was preferred, while scheduled exercise was rare. Interview-data added that PA was medicating, normatively described and accompanied by unfulfilled ambitions, particularly in low-SES BCSs. Balancing duties and activities was demanding. PA constraints were similar across groups. Domestic PA was important in low-SES, while high-SES BCSs described more energy.
Conclusion: Although PA levels among BCSs were similar across SES and equal to PA in the general population, SES differences became evident when measured by activity-logs and as stated in interviews. Future follow-up programs for BCSs could benefit from expanding the PA perspectives, thus better meet the needs of different SES groups.

Introduction

Breast cancer (BC) is detected in 1.7 million women globally every year [1] and is consequently the most common cancer in women. Estimates of BC survival rates in high-income countries range from 72% to nearly 100%, depending on BC stage at diagnosis [2]. Due to increasingly improved treatment methods aimed primarily at cancer elimination, BC survivors (BCSs) constitute a steadily growing group of persons who are living with residual

Abbreviations: PA, Physical activity; LTPA, Leisure time physical activity; OPA, Occupational physical activity; HPA, Housing physical activity; TPA, Transporting physical activity; SES, Socioeconomic status; HRQOL, Health related quality of life.

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challenges that affect their health-related quality of life (HRQOL) [3]. In order to facilitate return to normal life and reduce recurrence, BCSs are advised to engage in regular physical activity (PA). Previous studies have reported positive effects of exercise on HRQOL, risk of recurrence and mortality among BCSs [4–6]. However, cancer survivors are faced with several compounding factors [3], which each individual seems to handle differently. Thus, follow-up programs should extend beyond biomedical dimensions in order to facilitate regular PA among the socially diverse groups of BCSs.

In general, BCSs experience barriers to and facilitators of PA much similar to those among the general population [7], as lack of knowledge or enjoyment from PA, poor body image or discouragement [8], and lack of time and company [7,9,10]. Cancer-specific restrictions include fatigue, neuropathy and joint pain [7,11]. The proportion of BCSs who engage in recommended amounts of PA, equals the percentage of healthy women meeting such recommendations [12–14]; however, evidence indicates that there are PA differences across socioeconomic status (SES) groups. Previous studies have reported that highly educated BCSs are more physically active than less educated BCSs [15,16], and that public recommendations are less likely to be met by BCSs residing in low-SES neighbourhoods [17] and BCSs without university degrees [18] compared to their high-SES counterparts.

It is unclear whether social inequalities in PA among BCSs translate into social inequalities in BC survival rates. For a considerable time, higher education has been related to higher BC incidence and mortality. As of today, BC incidence rates have levelled off and mortality has declined [19]. Conversely, BC mortality rates have increased in women <50 years of age with lower SES [19,20]. Clearly, higher-educated women seem to have benefited the most from improvements in incidence and mortality [19]. Patient delays [21] are assumed to be significant determinants of the association between SES and mortality rates, as women with low SES tend to delay in consulting a doctor [22] and use less endocrine therapy [23]. However, an unhealthy lifestyle, including physical inactivity, is suggested to be equally as important as belated medical examination [24]. If this should prove to be the case, a better and more thorough understanding of how PA manifests differently across SES groups could contribute to more socially targeted BC follow-up. It is, however, important to be aware of the complexity of PA and challenges entailing traditional methods when PA is investigated.

PA, defined as *"any bodily movement produced by skeletal muscles that results in energy expenditure"* [25, p.129], is difficult to measure without introducing biases related to its constituents: type, intensity, frequency or duration [26]. Self-reporting questionnaires have been the most commonly used method for collecting data on PA levels [27], and seem also to be frequent in epidemiological studies of BC populations [28]. However, such questionnaires often include response options that are unable to accommodate the mental and physical fluctuations caused by for example fatigue and pain, which often hinder BCSs from undertaking regular PA. As a result, PA levels in BCSs with irregular PA might be misrepresented. Furthermore, inaccurate interpretations of total PA levels frequently occur, as questionnaires often lack information on occupational PA (OPA), transporting PA (TPA) or housing PA (HPA). To this end, we could add that the assumed positive relationship between SES and PA in the general population would seem to be mainly an association between education and leisure-time PA (LTPA) [29–31]. Hence, using traditional quantitative methods alone when attempting to understand PA may be insufficient, and probably introduces a risk of misrepresenting both BCSs and low SES groups.

Inspired by Engel's critique of the biomedical approach to illness [32] and in line with contemporary health-behaviour models [33,34], it could be argued that a multi-perspective understanding of PA behaviour in long-term BC survivorship, including both qualitative and quantitative dimensions of PA, could direct greater attention to the specific challenges of all sub-groups of BCSs. Hence, knowing that lack of time, in combination with fatigue, is a pronounced challenge among BCSs [7,11], and that time scarcity may be related to social health inequalities [35], approaches depicting BCSs' time-use might allow important, but previously overlooked, aspects of these variables to surface. In addition, as barriers to PA among BCSs seem to vary across SES groups [36], BCSs' in-depth descriptions of their experiences with PA could further our understanding of the specific challenges of each sub-group of BCSs for engaging in PA.

The aim of the present study was therefore to a) identify levels of-, daily routines for- and experiences with PA among long-term BCSs, in general and on the part of SES groups, and b) explore whether a mixed method approach might unveil diversities of PA practice in BCS across SES groups.

Methods

A total of 250 BCE patients referred for postoperative irradiation at a Norwegian university hospital in 2007–2008 were enrolled in a longitudinal follow-up study concerning HRQOL and late effects. The recruitment procedures and baseline sample characteristics are described elsewhere [37]. Participants for the present sub-study were recruited at the main study's 7–8 -year follow-up check at the outpatient cancer clinic. All participants were invited to be interviewed or to write an activity-log, or both. At the time of invitation, 71 women from the baseline sample had completed a follow-up questionnaire for the main study. Thirty-seven of these women volunteered for interviews and 52 for activity-logs (Table 1).

Self-reported data on PA and socio-demography were extracted from the main study questionnaire, and filed in SPSS (v25).

Notebooks were handed out at follow-up controls, requesting records of time, place and company (and possibly comments) for each activity. All activities throughout a 24-h day were to be logged for ≥4 days (one had to be a Sunday). Logbook-data were transferred into Vardagen [38] and VISUAL-TimePAcTS [39].

Semi-structured in-depth interviews were conducted to explore the women's care pathway, daily activities, and HRQOL and health. The perceived meaning of PA, personal grounds for being physically active, and expectations regarding appropriate PA participation, were touched upon while talking about daily activities and health perceptions. The interviews were transcribed verbatim and filed in NVivo (QSR, v11).

Measures

In the *questionnaire*, PA was measured as frequency (<1 bout/week; 1 bout/week; 2–3 bouts/week; daily), intensity ('no sweat or heavy breath'; 'heavy breath and sweat'; 'push myself to exhaustion'), duration (≤15 min; 16–30 min; 31–60 min; >60 min), and type (walk/jog/run; ball playing; Nordic skiing; bicycling; swimming; studio; martial art; dance; other). SES was determined as level of education (Low:{primary and lower secondary; upper secondary; high school}; High: {college degree; university degree >3 years}), household income (NOK1000 ≈ €100): (Low:{<100; 100–299; 300–499}, High: {500–699; 700–899, ≥900}), and work status (employed; partly employed; home working; unemployed; partly on sick leave; on sick leave; rehabilitation; disability pension; retired; student).

In *activity-logs*, PA was measured as frequency (bouts counted), intensity ('no sweat or heavy breath' unless commented

Table 1
Participant characteristics in study samples. Frequencies (%).

	Logbook/ survey sample (n = 52)		Interview sample (n = 37)	
Age at follow-up:				
Mean [range][SD]	62 [31–87] [10.0]		61 [43–87] [9.8]	
Mode	67		60	
Marital status:				
Married or cohabited	42	(81)	24	(65)
Divorced	5	(9)	5	(14)
Single	2	(4)	5	(14)
Widowed	3	(6)	3	(8)
Socioeconomic status:				
Education:				
Primary and lower secondary (1–6, 7 or 9 years)	6	(12)	5	(14)
Upper secondary, basic (<12 years)	25	(48)	18	(4)
Upper secondary, final (12 or 13 years)	7	(13)	6	(15)
College degree (3 years)	4	(7)	4	(11)
University degree (>3 years)	8	(15)	4	(11)
Unknown	2	(4)	0	(0)
Household income (1NOK ≈ 0,1 Euro):				
100.000–299.999	7	(13)	9	(24)
300.000–499.999	12	(23)	9	(24)
500.000–699.999	13	(25)	7	(19)
700.000–899.999	11	(21)	6	(16)
>900.000	7	(13)	5	(14)
Unknown	1	(2)	1	(3)
Work status:				
Employed	14	(27)	11	(30)
Partly employed	8	(15)	4	(11)
Unemployed	1	(2)	1	(3)
Partly on sick leave	2	(4)	3	(8)
Sick leave	1	(2)	0	(0)
Disability pension	9	(17)	8	(22)
Retired	17	(33)	10	(27)
Types of BC treatment:				
Breast conserving surgery	30	(58)	20	(54)
Radical (mastectomy) surgery	22	(42)	17	(46)
Chemotherapy (adjuvant/neo-adjuvant)	32	(61)	25	(68)
Endocrine treatment	35	(67)	13	(35)
Trastuzumab	19	(36)	12	(32)

differently), duration (min. from activity start to activity end), and type (as logged). Additional measures were 'time of day in PA' (asleep–08:59; 09:00–14:59; 15:00–19:59; 20:00–sleep), 'PA company' (alone/not alone), 'PA places' (described), and 'daily-life activities before/after PA' (as logged).

The *interview* transcripts provided data on occupation and utterances about PA.

Data analyses

A parallel mixed analysis was conducted, although full sample analyses of questionnaires and contrasting case analyses of logs and interviews were run sequentially [40] to detect SES differences. The analyzing phases are presented in Table 2.

Ethical issues

All participants signed a new informed consent form. We will refer to the participants by fictitious initials in order to retain anonymity.

Results

Rates of PA type, -frequency, -intensity, -duration and activity categories, assessed from activity-logs and questionnaires, are given in Table 3[3] Questionnaire data showed that 83% ($n = 43$) of the BCS walk/jog/run, and that 38% ($n = 20$) cycle when exercising. By comparison, the most logged LTPA or TPA was walking (43 occasions). Gardening, which was not specified in the questionnaire, was logged on 12 occasions. There were small differences between questionnaire-reported and logged frequency of PA. The intensity, however, differed between questionnaire-data and log-data, as 38% ($n = 20$) of the BCSs reported that they exercised with 'no sweat or heavy breathing', whereas such intensity was logged by 96% ($n = 50$). Further, 53% ($n = 28$) BCSs usually exercised with 'heavy breathing and sweat' according to the questionnaires, while 21% ($n = 11$) had logged this level of intensity. Finally, the total duration of PA reported in the questionnaires ranged from 0 to 420 min/week, whereas for logs, the duration ranged from 0 to 1205 min.

Questionnaire data showed that 35% (n=18) were 'physically active' according to calculations based on questionnaire registered PA duration, as were 54% (n=28) when intensity was included in the calculations. The corresponding numbers for activity-logs were 63% ($n = 33$) and 23% ($n = 12$). A total of 337 days was logged as activities for 5 days ($n = 8$), 6 days ($n = 4$), and ≥one week ($n = 40$).

Additional daily-routine data from the activity-logs showed that the total number of times/week the BCSs engaged in TPA or LTPA ranged from 0 to 21. The preferred location for LTPA was neighbourhood surroundings including gardens and areas close to the cabin. Being in the woods, the hills or by the seaside was the second choice. Swimming pools, gyms and dancing venues were occasionally registered. TPA involved primarily transport to paid work, and less often to other locations. All TPA was registered without partner(s), but 55% of LTPA (including gardening) bouts were performed together with a partner. Most of the PA took place between 9 a.m. and 3 p.m., although early-morning or evening bouts were common.

The interview analyses ($n = 37$) confirmed that walking was the preferred PA, albeit stories about alternative activities were told. Six additional themes emerged from the analyses: 'positive associations to PA', 'fulfilling ambitions or not', 'PA constraints', 'the art of balancing duties and leisure time activities', 'to appear physically active', and 'strategies for PA'. Fig. 1 provides a depiction of these themes, followed by representative quotes.

SES-related differences in PA

Results from SES-related analyses are presented in Table 4 and Fig. 2. PA duration assessed by *questionnaire* ($n = 50$) did not differ significantly between high- and low-income groups (not shown), or between high- and low education groups. PA frequency was equal across dichotomised educational levels. However, the intensity was higher in BCSs with higher education than in BCSs with lower education. Walk/jog/run was the most reported PA type in both groups, but a higher percentage was seen in the higher-education group. Parallel *activity-log* analyses (n=8 + 9) showed a significantly higher number of LTPA or TPA bouts among high-SES BCSs (p = .002) (see also Fig. 2). However, there was no significant difference in the number of min/week in LTPA or TPA between the groups (p = .15).

Further, neighbourhood surroundings were the most preferred location for PA in both SES-groups, although TPA was equally prevalent in high-SES BCSs. Fig. 2 depicts activity-logs as diagrams (low-SES logs in top row). The 7-coloured lines at the bottoms of the left cell represent a 7-day week. Vertically, each participant's

[3] Due to too sparse descriptions of HPA, although logged in 175 days, the table includes LTPA and TPA exclusively.

Table 2
Phases of analysis.

General analyses
First, to avoid an untimely identification of SES differences in PA leading to a debilitated qualitative analysis, *interviews* ($n = 37$) were probed, and any texts dealing with PA were extracted. Each excerpt (5–17 pages) was inductively analysed thematically. Two researchers agreed on the initial and ensuing grouping of family codes, aiming at an uncomplicated number of thematic categories.[1] Codes, family codes and themes, upon which there was no agreement, were discussed and redefined. On this basis, one researcher coded the remaining transcripts
Descriptive analyses of frequency, intensity, duration as well as type of PA from *questionnaire* data ($n = 52$) were run. 'Activity level' was based on a) duration of LTPA and TPA (PA ≥150 min = 'active'. PA <150 min = 'not active') and b) intensity *and* duration of LTPA and TPA (PA ≥60 min with 'heavy breath & sweat' = 'active'. PA <60 min and/or lower intensity = 'not active')
TPA, any physical exercise, hiking or walking and other physically demanding activities from other DLAs in the *activity-logs* were extracted. Descriptive analyses of frequency, intensity, duration and type of PA, as well as time of day, types of DLAs connected to PA, venues for PA and PA-company, were run
'Activity level' from *log-data* were calculated, as done for questionnaire data
Questionnaire data and *log-book* data were compared in terms of PA duration, -intensity, -frequency, -type and 'activity level'
Results from interview analyses were brought in, in order to supplement the results from questionnaire and log-book analyses
SES-analyses
Mann-Whitney U tests were run for differences between high- and low-income group and between high- and low-educational group regarding *min/day in PA*, *frequency* and *intensity*, assessed by *questionnaires* ($n=50$)
Based on a combined rank of (highest and lowest) educational level, income and occupation, two SES sub-samples ('high SES' ($n = 8$) and 'low SES' ($n = 9$)) were selected for comparison of potential SES differences in *interview data* and *log-data:*
Two researchers coded the SES-determined sets of *interview* transcripts independently and unaware of SES- membership. The same procedure as in the full sample analysis was followed. Related themes, which emerged from each set, were discussed, and redefined into joint themes[2]
Descriptive comparisons of 'types and places of PA', 'DLA before/after PA', 'time of day in PA' and 'PA company', assessed in activity-logs, were conducted
Mann-Whitney U tests for differences in PA bouts/week and min/day assessed in activity-logs between the SES subsample groups were run.

[1] Example: we linked family codes such as 'impossible to both exercise and work' (based on inter alia 'work has taken over' and 'lack of physical surpluses') and 'self-regulated amount of exercise' (based on inter alia 'balance exercise and rest' and 'exercise when I feel ready') to the theme 'the art of balancing duties and leisure time activities'.

[2] Example: 'active outdoors', 'the cabin' and 'transport' were common family codes grouped into the descriptive theme 'how BCSs are physically active', but the codes contained different information dependent of SES group. For instance, within the family code 'transport', low-SES BCSs spoke mostly about car transport, while high-SES BCSs more often spoke about walking or cycling. Likewise, in the family code 'active outdoors', high-SES BCSs related strenuous hiking *in addition* to the short walks that were common also among low-SES BCS.

Table 3
LTPA and TPA measured by questionnaires and activity-logs completed by 52 BCSs. Frequencies (%).

	Questionnaires			Activity-logs		
Type[a,b]	Walking, jogging, running	43	(83)	Walking/hiking	43	
	Bicycling	20	(38)	Gardening	12	
	Studio	12	(23)	Bicycling	7	
	Skiing	11	(21)	Studio/exercising	11	
	Swimming	7	(12)	Swimming	4	
				Dance	1	
Frequency	Every day	12	(23)	Every day	12	(23)
	2–3 days/week	24	(46)	2–3 days/week	29	(56)
	= once a week	11	(21)	= once a week	9	(17)
	< once a week	5	(9)	< once a week	2	(4)
Intensity[c]	No sweat or heavy breath	20	(38)	No sweat or heavy breath	50	(96)
	Heavy breath and sweat	28	(53)	Heavy breath and sweat	11	(21)
	Push myself to exhaustion	1	(2)	Push myself to exhaustion	8	(15)
	Not assessed	3	(6)	No activity	2	(4)
Duration	Total (average) minutes	0–420		Total minutes	0–1205	
Active	Active; 150 or more min/week[d]	18	(35)	Active; 150 or more min/week	33	(63)
	Active, intensity included	28	(54)	Active, intensity included	12	(23)

[a] The question allowed for more than one answer, hence the total number of replies exceeds 52.

[b] Log data refer to the number of times an activity was logged, which renders percentages impossible.

[c] Questionnaire data refer to the numbers of BCSs who answered the given average intensity during a normal week. The log data refer to numbers of BCSs who in fact had logged PA in said intensity during the week in which they logged activities.

[d] Calculations based on response options means, e.g. 2–3 bouts/week in 31–60 min = 2,5 × 45min = 113 min.

24-h days are represented by bars, of which all time spent within different PA domains is coloured. Nine exercise sessions (green bricks in the left bottom diagram) were logged by BSCs in the high-SES group as were 2 by BCSs in the low-SES group (left top diagram). The diagrams in the centre column show the sum of activities per PA-domain logged at different hours throughout the week (including exercise, gardening, other LTPA and TPA). There were hardly any visible differences between the SES-groups in the time of day spent in PA. To the right, logged HPA is added, showing the contribution of HPA to total PA. On average, HPA occupied 6.6 h/week in low-SES BCSs, and 5.7 h/week in high-SES BCSs (numbers not shown).

Subsample *interview* analyses added that although the two SES groups experienced similar challenges relevant for PA, they differed in *'how, and with whom they are active'*, their *'energy levels'*, and their *'approach to PA'* (presented condensed in bottom rows of Table 4):

Both groups engaged in walking, but there was a propensity for short walks among low-SES BCSs. Sustained activities, such as mountain hiking, hours of marching (band) rehearsals, or extensive gardening were reported among high-SES BCSs. Moreover, whereas low-SES BCSs reported both active and inactive transport, high-SES BCSs reported little motoring. Furthermore, spending time and energy on family and housekeeping seemed important to low-SES BCSs.

The need for rest was expressed by almost every BCS. High-SES

Fig. 1. Themes revealed from interview analyses of all interviews, followed by representative quotes.

BCSs tended to feel fit after a nap, whereas no such tendency was found in the low-SES group. Instead, the importance of being busy (and not appearing lazy) was noticed among low-SES BCSs. High-SES BCSs reflected high energy levels by being engaged in physically demanding activities, and by aspiring to even further engagement. The importance of balancing activities and duties was also more explicit in high-SES BCSs. Lastly, although the majority reported being in good health, the low-SES BCSs emphasised clearly how years of working had worn them out.

The trend that PA was associated with bad conscience emerged as evident primarily in low-SES BCSs. Analyses of interviews of high-SES BCSs revealed a deliberate choice to be engaged in PA after BC. The will to make every effort to accomplish planned exercise was, in the same way, noticeable in high-SES BCSs. An energetic

Table 4
PA among BCS with high and low SES based on data retrieved from questionnaires, logbooks and interviews.

	High education (n=20) (%)		*Low education (n=30) (%)*	
Mean age	55		67	
Household income >500.000 NOK	17	(85)	14	(47)
PA in TOTAL SAMPLE OF QUESTIONNAIRE (n = 50)				
PA ≥150 min.	9	(45)	8	(27)
Active[a]	13	(65)	14	(47)
≥2–3 times/week	14	(70)	21	(70)
≤1 time/week	6	(30)	9	(30)
Light	4	(20)	14	(47)
Get sweaty	12	(60)	16	(53)
Exhausted	1	(5)	0	–
No answer	3	(15)	0	–
Walk/jog/running	14	(70)	27	(54)
Skiing	6	(30)	5	(6)
Bicycling	7	(35)	13	(43)
Swimming	3	(15)	4	(13)
Studio	8	(40)	13	(43)
Combat sports	0	–	1	(3)
Dancing	0	–	1	(3)
Other	6	(30)	6	(20)
***PA in* SUBSAMPLE of LOGS:**	***Highest SES (n=8) (%)***		***Lowest SES (n=9) (%)***	
Average min/day	76		46	
Average bouts/week[b]	13		5	
Walking the dog	33		9	
Gardening	9		3	
Short/long walks	10		22	
Exercise	7		0	
Dance	0		1	
Swim	2		0	
TPA	43		15	
Places in PA (104 reported)	Neighbourhood surroundings 43	(41)	Neighbourhood surroundings 30	(59)
	The woods/hills/seaside 13	(13)	The woods/hills/seaside 7	(14)
	Gym (incl. sports hall or pool) 5	(5)	Gym (incl. sports hall/pool) 0	–
	Dancing venue: 0	–	Dancing venue 1	(2)
	Between places: 43	(41)	Between places 15	(29)
DLAs before and after PA (typical)	Before: Food(related), rest, morning toilet, social, night sleep, work, doc's, organization After: TV, rest, work, social, night toilet, night sleep, doctor's visit, organization		Before: Food(related), rest After: TV, rest, work	
Time of day in PA	00:00–08:59: 24% 15:00–19:59: 37.5% 09:00–14:59: 28% 20:00–23:59: 9.5%		00:00–08:59: 21.5% 15:00–19:59: 24% 09:00–14:59: 45% 20:00–23:59: 10%	
PA company	Without company in 33–87% of all bouts		Without company in 0–100% of all bouts	
***PA in* SUBSAMPLE of INTERVIEWS**	***Highest SES (n = 8)***		***Lowest SES (n = 9)***	
How BCSs are physically active, and company	Walks (both long lasting and short), low motoring levels, frequently visiting holiday house for recreational activities. Various company, but the joint project is important		Short walks, inactive commuting between places, hardly ever-visiting holiday house. Various company.	
Energy levels and fitness	Lower than before diagnosis. Engaged in demanding activities beside PA. Desire to further engagement and the tediousness of doing 'nothing'. The art of balancing rest and total PA.		Lower than before diagnosis. Importance of (appearing) being occupied by housework. Lower energy level could be explained by being older.	
Approach to PA	PA is good, and I certainly want to do it no matter the pain and my limitations		PA is good, and I try my best or should have done more	

[a] PA for at least 60 min/week, producing 'heavy breath or sweat'.
[b] Significant difference between groups.

attitude was reflected also in the ability to ignore the pain that could arise from some types of PA, and to follow partners' exercise regimes.

Discussion

The aim of the present study was to a) identify levels of-, daily routines for- and experiences with PA among long-term BCSs, in general and by SES, and b) explore whether using complex mixed methods analyses of data from one sample might expand current knowledge of PA practice in BCS. We found that 23–63% were categorized as physically active, depending on the method for calculating PA level, and that walking was the preferred type of PA. The most common daily PA routines were individual outdoors activities in the BCSs' home or cabin surroundings, and TPA, mainly to work. PA was described as a positive experience, yet infrequent, however difficult to balance against duties and pronounced needs for rest. SES differences, which became evident when activity-logs and interviews were analysed, were mainly about higher intensity and more LTPA in high-SES BCSs, as opposed to obligations to HPA

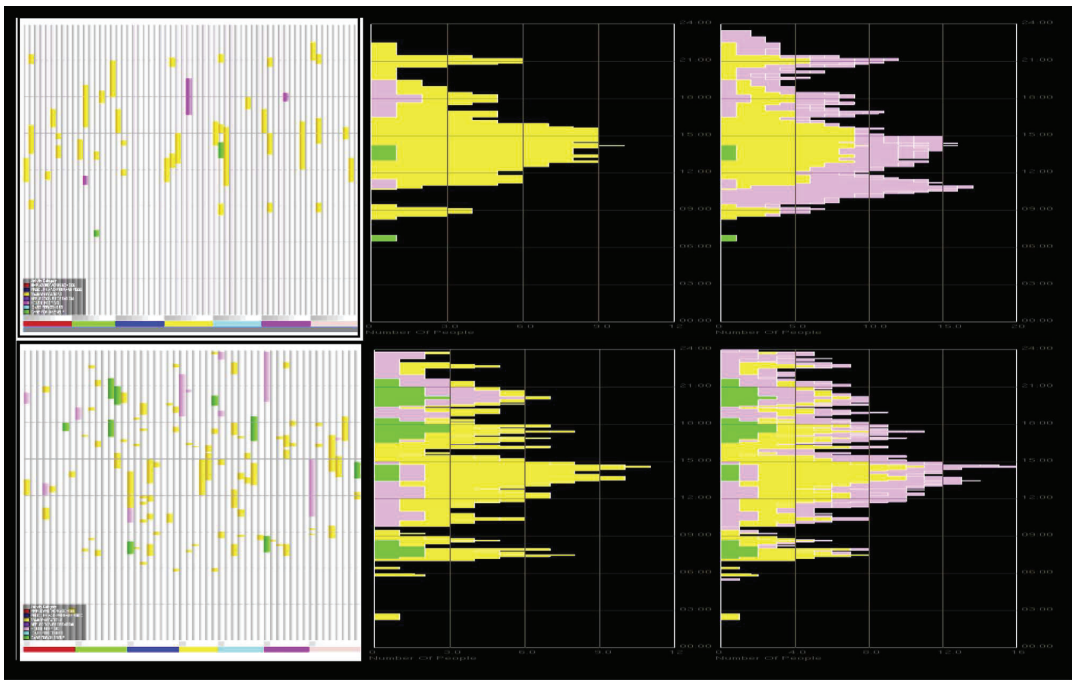

Fig. 2. Activity-log depictions [39] of daily time-use within domains of PA in BCSs with high (bottom row) and low (top row) SES. Left column: coloured lines symbolise a 7-day week. Vertical bars represent each participant's 24-h days. Time spent within different PA domains is marked with colours (exercise PA = green, gardening PA = pink, other LTPA and TPA = yellow). Center column: the sum of registrations within exercise PA, other LTPA and TPA, and gardening PA, logged at different hours a day during the week. Right column: HPA is added (extended pink areas).

and valuations of not appearing lazy, among low-SES BCSs. Across the three different data sets, results confirmed and complemented, but were as well contradictory.

The quantitatively measured PA-levels showed that BCSs seem to equal (or even surpass) women in the general population in terms of meeting national guidelines of 150 min/week of moderate PA, as 35% of Norwegian females met such guidelines in 2014 [41]. First, this finding corresponds with results from Irwin et al. [12], where the PA-levels of BCSs' were equal to PA-levels in general. Although previous studies [12–14], as well as the present one, demonstrate that the majority of BCSs are less physically active than what is recommended, they show that BCSs as a group do not perform less well than other women. Previous habitual PA practice as well as participation in rehabilitation programmes that include PA education for BCSs may account for their rather high PA levels. Taken together with the possibility that physically inactive BC patients were ineligible to participate in our study due to illness, or they were dead, the sample's average PA-level may be somewhat higher than what is fully representative for the BCS population. On the other hand, questionnaires have previously been reported to allow for over-reporting PA levels [42], also among women diagnosed with BC [43]. The fact that the relationship between duration and intensity of PA appeared inverse for log-data compared with questionnaire-data in the present study, probably illustrates such phenomenon. Although the intensity of PA reported in activity-logs might have been underestimated, the interviews, which were made with the same individuals, confirm that most PA among BCSs was at a rather low intensity. Regardless, the reality of PA among BCSs is likely much more nuanced than we can read from traditional quantitative data.

Low education is often cited as an important determinant of poor health [44], implying that, insufficient PA-levels may be understood in light of poor health literacy [45]. Although many BCSs in our study were insufficiently active, almost none identified themselves as non-active according to the interview-data, as they talked a lot about how being physically active positively affected their experienced late-effects after BC treatment. Additionally, their references to previous PA-levels and their wish to appear busy, together with reflections upon their perceived PA-level, indicate sufficient knowledge about the impact of PA. Instead, explanations may lie in the combination of late effects shared by cancer survivors [7,11] and general barriers to PA [7–9]. Although such constraints could reflect excuses as much as true barriers to PA [46], something that is not exclusive to the BCS population, their negative effect on BCSs' ability to comply with appropriate health advice may increase as they interact. At least in the case of BCSs in the present study, extra health education regarding PA seems redundant.

Conceptual confusions regarding PA are common, and it should be noted that our statistics were based exclusively on two domains of PA, TPA and LTPA. Thus, the findings are less valid in terms of the definition offered by Caspersen et al. [25] as mentioned earlier. Insufficient data on HPA and OPA may have led to misconceptions about real PA levels in BCSs who are inactive during leisure time, but may have physically demanding occupations or domestic obligations. Similar misconceptions have received attention in previous reviews [29–31] and have also been recognised in studies of BCSs [12,36]. Further support for such claims can be found in a study of PA in older retired men, which demonstrated that daily

activities could account for at least as many Metabolic Equivalent for Tasks (METs) per week as is recommended [47]. Thus, complementing questionnaire PA data with activity-logs reveals significant information. A majority of the BCSs in the present study were no longer working, thus they would not report any current OPA; however, HPA was logged every other day. Therefore, even more BCSs might have been categorised as 'physically active' had all PA-domains been included in the analyses. Again, the qualitative data, retrieved from the same sample as were log- and questionnaire-data, support such a hypothesis, as many daily physical activities were described among the total activities that the participants employed in their daily life. Hence, for some BCSs, their perceived level of total PA might better reflect the true level of total PA than does the level derived from the quantitative analyses.

Pre-set response options in PA questionnaires, often designed for the normal population, are unable to accommodate possible fluctuations that hold BCSs back from regular PA. For the majority of BCSs in our study, weekly PA routines were mostly related to outdoor walking, and much less frequently to regularly time-set exercise, which is consistent with previous studies [36,48]. Besides confirming the preference for walking, our supplementary data from activity-logs and interviews demonstrate how neighbourhood walking, at hours that suit the BCS, makes it easier to deal with exhaustion or fatigue. The opportunity for easy access, as well as easy return home, together with feelings of immediate and tangible health effects, seem to render such PA largely effortless. Although recognisable, these findings might counter a common misunderstanding, also reflected in several of the interviews, that scheduled, strenuous exercise is crucial for leading a physically active life. The health effects of daily PA, such as walking, are evident [49], and several studies support the hypothesis that sedentary behaviour is as significant for health as is LTPA duration [50]. Furthermore, as is evident from our log and interview data, the mental and physical fluctuations experienced by many BCSs affect their PA practice to a considerable degree. Balancing duties and leisure time activities in a way that makes both of them manageable was associated with an extended time-use compared with time use prior to diagnosis. A preference for not scheduling PA, or having days off from paid work, relates to the freedom to work as well as engaging in leisure activities *and* rest when necessary. Overall, the present results reveal the need for flexibility in everyday life and demonstrate how quantitative questionnaire reports of an 'average week of PA' might result in misinterpretations of PA levels in BCSs.

It is unclear whether the level of PA contributes to social inequality in BC survival and HRQOL in later life. In such cases, there are reasons to suggest that knowledge about domain specific PA is important, and not only that of the overall level of PA. In our material, no significant associations were found between SES and 'active' categories, whether based on both duration and intensity of PA, or exclusively on duration. These results are inconsistent with previous studies accounting for both the intensity and duration of PA, which have reported that BCSs who have completed higher education are more physically active than BCSs with lower education [15–18]. Our results may of course, be explained by the small sample size. However, as a reminder of the significance of considering all PA domains, the activity-log figures, which show a higher proportion of HPA in low-SES BCSs compared to high-SES BCSs, indicate the relative significance of HPA for total PA. Also, further elaborated in the interviews, the low-SES BCSs, in clear contrast to the high-SES BCSs, stressed that domestic work was highly appreciated, and that such activities reflected their level of busyness. On the other hand, high-SES BCSs focused on leisure-time activities as being undertaken for their own well-being. Obviously, differences in age and employment status could explain such patterns in LTPA, TPA and HPA, as the high-SES BCSs were on average ten years younger and working, thus having less time for housework and gardening, and were expected to be more physically fit for strenuous activities. However, previous studies support the possibility that such results could relate to SES. For example, Owusu et al.'s results indicate that family background could influence decisions regarding PA among BCSs [36], and Ball et al. indicated the notion that preferences for different types of PA in women are dependent on SES [51]. From our own data, we could add that although a majority of the low-SES participants were retired and thus not engaging in OPA, many of the women felt worn out from heavy workloads in their previous working life. There are reasons to believe that such weariness is likely to affect their current level of LTPA. In any case, the fact that we detected SES differences after analysing complementary data, should remind us of the risk of misinterpreting data when using one method (albeit well established) regardless of the context.

Previous results of SES differences in PA among BCSs are consistent with social health inequalities in general [52]. However, research samples will rarely be sufficiently representative across SES groups as long as high-SES individuals volunteer for participation more frequently than low-SES individuals [53,54]. The Declaration of Helsinki clearly prevents researchers from obliging vulnerable groups to participate in studies with the aim of obtaining representative samples, unless it is of the outmost importance [55]. The most vulnerable BCSs, i.e. those with severe late effects and lowest SES, are therefore least likely to participate in studies such as ours. Although our combination of methods aims to provide previously overlooked information for the benefit of low-SES BCSs, the real SES differences might be even greater than we have been able to identify. Finally, our results should be interpreted in light of the Norwegian context. More specifically, the transferability of our results to other countries and regions may be limited by the fact the proportion of higher educated is larger in Norway than elsewhere. This can be illustrated by the fact that in populations with larger proportions of high educated and smaller proportions of low educated, the excess mortality among intermediate and low educated is larger, all other things being equal [56].

Conclusion

The levels of PA in long-term BCSs were not different from PA levels previously reported for the general population. Neither were there any significant differences in PA levels between BCS SES groups. However, SES differences in PA were evident in terms of their routines for- and experiences with PA as measured by activity-logs as well as what was stated in interviews. Thus, important additional information about BCSs' PA was uncovered by including the latter two data sets in the mix. Combinations of qualitative and quantitative methods, including an increased use of activity-logs at the expense of traditional questionnaires, may therefore be recommended in future studies to get a more accurate and balanced picture of PA among BCS. In addition, follow-up programmes for BCSs could benefit from expanding the PA perspective to include more dimensions of PA, and thus better meet the needs of different SES groups.

Ethical standards

The study was conducted in accordance with the Declaration of Helsinki and was approved by The Regional Committee for Medical and Health Research Ethics (REC Central 2009/108.4.2006.2856). All participants signed a new informed consent form before undertaking any procedure related to the present study.

Declarations of interest

None.

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Paper III

Do breast cancer patients manage to participate in an outdoor tailored physical activity program during adjuvant breast cancer treatment?

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Abstract

Background: Exercise may reduce side-effects of adjuvant breast cancer treatment, but whether and how study design and patient characteristics affect adherence to exercise interventions remain unclear.

Purpose: To study adherence to an outdoor 12-months post-surgery exercise program during adjuvant breast cancer treatment.

Method: A total of 47 women diagnosed with invasive breast cancer (Stages I–II) or ductal/lobular carcinoma in situ (DCIS/LCIS III) were randomized to 12 months outdoor post-surgery group exercise (2 days/week). Patients characteristics (age, body-mass index (BMI, kg/m^2), socioeconomic status, comorbidity, physical activity level and maximal oxygen uptake) were recorded pre-surgery. Correlations between adherence and patient characteristics, and pre-surgery physical activity level. Statistical tests for between-group differences were run.

Results: The participants had a mean age of 54.2 years and mean BMI of 27.8 kg/m^2. Among these women, 54.2% received chemotherapy. Completers (77%) had a mean adherence to out-door group exercise of 81% and to unsupervised physical activity of 230%±213%. Women who did not fulfil the group exercise sessions (23%) withdrew from exercise sessions after a mean of 6.5 weeks (0–24 weeks). No significant correlations between adherence and health conditions or sociodemographic characteristics were found, although tendencies were observed for higher age and income. Seasonal differences were due to holidays, and no significant quarterly variations emerged.

Conclusions: Our study supports that breast cancer patients during adjuvant treatment may have high adherence to a 12-months tailored outdoor group exercise program, but additional studies are needed to clarify the need for follow-up in some groups of women.

Key words: Breast cancer, physical activity, adherence, withdrawal, sociodemographic, outdoors intervention

Introduction

Physical activity has consistently been observed to reduce the risk of postmenopausal breast cancer in a dose-response manner with about 20% reduction in risk, and the greatest reduction have been observed for leisure-time physical activity [1-3]. In addition, previous studies indicate that physical activity during adjuvant breast cancer treatment may reduce unfavourable side-effects [4] and suggestively reduce recurrence and increase survival [5-8]. Thus, these findings, also including potential effects on physiological and psychological outcomes have directed trials aiming at verifying such relationships. Recent studies support that physical activity may improve physical fitness [4,9-11], physical functioning [10,12,13], fatigue [4,10,13,14], and quality of life [4,10,13] in breast cancer patients.

Participants' adherence to the prescribed physical activity program has been a major challenge in physical activity intervention studies in general [15]. Furthermore, contemporary combined adjuvant breast cancer treatment may be challenging [9] and may often give immediate side-effects such as nausea, fatigue, hair loss and chills [10]. As a consequence, it may be difficult to maximise physical activity intervention adherence [4]. Many patients report that the abovementioned side-effects, in addition to the mental strain of being severely diagnosed, affect their attendance to physical activity interventions [13]. Furthermore, medical complications, deterioration of medical condition, personal or social problems have shown to lead to withdrawal from physical activity interventions among breast cancer patients during adjuvant treatments [14].

The effect of physical activity depends on the type and doses (the combination of frequency, duration and intensity) of physical activity and the point in time during the period of treatment. Furthermore, the effect depends on the possibility to participate, and to perform physical activity in secure and trustworthy settings, and consequently, on the ability to accomplish the types and doses of physical activity to achieve the intended effect. Previous trials involving physical activity in breast cancer patients vary in settings that may influence on the adherence rates. For example, shorter (3–6 months) than longer interventions (1–2 years) have been reported to have higher adherence rates [16], whereas in patients >50 years, home-based exercise sessions increase attendance rates compared to centre based programs [17]. Moreover, higher adherence rates have been reported in supervised exercise programs as compared to unsupervised physical activity programs [18], and, despite insufficient compliance reports in terms of, for example, intensity, duration, and resistance training repetitions, less physically demanding interventions are associated with higher adherence than trials involving more strenuous physical activity [18]. Assessing the abovementioned aspects as regarding intervention

feasibility is important in order to properly translating research results into clinical recommendations.

Nevertheless, thorough knowledge about which breast cancer patients have difficulty in participating in physical activity is essential when it comes to who needs extra follow-up during treatment and rehabilitation. Variables such as age and menopausal status, time since diagnosis, tumour stage, type of cancer treatment, previous experience with leisure-time physical activity, occupational physical activity burden, and sociodemographic distribution could affect the adherence rates. Some evidence seems however inconsistent. In the PACT-study, receiving radiotherapy in addition to chemotherapy, predicted low attendance to supervised exercise [19], yet another randomised trial from the United States showed that receiving chemotherapy was associated with better adherence to a short-term home-based walking exercise program when compared to receiving radiotherapy [20]. In a one-year Danish randomised intervention study, it was observed that receiving neo-adjuvant chemotherapy increased the chance of adhering to the supervised exercise compared to receiving adjuvant or no chemotherapy [21]. Having an advanced cancer stage was associated with higher adherence to supervised physical exercise through one year's intervention [22] but was significantly associated with lower completion rates in a 6-months exercise trial in premenopausal patients [23]. Higher body mass index (BMI) seems to predict lower adherence both to supervised exercise [19,24] as well as to home-exercise [21]. Further, higher adherence has been associated with fitter patients [22,24], less depressed patients [18] and a perceived interest in exercise [25], whereas sedentary baseline behavior [26], higher levels of fatigue (16) and low lower-body muscle strength at baseline [21] has been associated with lower adherence rates.

Despite the growing evidence of social health inequalities, only a few randomised physical activity trials studying women undergoing breast cancer treatment have assessed adherence to the intervention across socioeconomic status [21,24,25,27,28]. Still, higher educational level seems to predict higher adherence to physical activity in some breast cancer patient populations [19,24]. In a Taiwan study, being employed was associated with better intensity adherence [25]. Related to this are also socioeconomic differences between intervention completers and withdrawals, which are found to be either non-existent [28,29] or dropouts are more likely to be unemployed or have lower education than completers [27]. For the case of social health inequalities, the relative odds of being diagnosed with breast cancer in a more advanced tumour stage have been observed to be higher in women with low compared to women with higher socioeconomic status [30,31]. In Norway, lower attendance rates to mammographic screening are observed among women with low educational levels [32]. Moreover, high-socioeconomic individuals have been observed to more often participate in trials than do their low-socioeconomic

counterparts [33,34]. These findings illustrate the importance of being transparent when it comes to a study's withdrawal and sample characteristics as being the basis for the results. The risk of a study being accused of poor external validity and impeding important insight into systematic differences in patients' ability to complete the intervention is otherwise imminent.

The main aim of the present study was therefore to investigate overall and quarterly adherence to an outdoor 12-month post-surgery supervised exercise intervention among breast cancer patients receiving adjuvant treatment, and to identify possible predictors of adherence, such as sociodemographic and health variables.

Methods

Participants and study design

Women aged 18–75, diagnosed with ductal/lobular carcinoma (DCIS/LCIS) grade III or invasive breast cancer stage I–II were invited (before surgery) to participate in a prospective two-armed 12-months physical activity intervention trial, and randomised 10+/- 2 days after surgery. The current study included all patients enrolled at 'XXX' Hospital, 'XXX', Norway, between September 2014 and June 2017. The inclusion required Norwegian language skills and the ability to complete 12 months physical exercise intervention. We excluded patients with known severe illnesses (i.e. heart disease, dysregulated diabetes, thyroid disorders), BMI <18.5 kg/m^2 and > 40 kg/m^2, previous bariatric surgery, and with a travel distance >1.5 hour from home to study site (for practical/logical reasons).

After completion of baseline assessment and surgery, the participants were randomly allocated 1:1 to either the intervention or to the control group. They were stratified by menopausal status (menstruation stopped for ≥12 months, or age ≥55 years). In total, 47 patients were randomized to the intervention group (Figure 1).

Physical activity intervention

The physical activity intervention program was developed particularly for this trial and based on national and international exercise expertise and programs [35-37]. The program included aerobic training of moderate-to-high intensity as well as stretching and weight bearing activities. Each patient randomized to the intervention group had an initial individual session with a trained physiotherapist and received a detailed individualized training program based on their own physical function and capacity. The participants were then organized into training groups, with 8-12 patients in each group, and started exercising 21-28 days post-surgery. The group sessions were performed during the working hours, outdoors in a Nordic climate, and in all kinds of weather, for 60 minutes two times per week, for 12 months. The participants were instructed to do unsupervised physical activity of at least moderate intensity at home

for minimum 120 min/week, resulting in a total of 240 minutes of exercise per week. The patients were also asked to submit logs of type, duration and intensity of all physical activity completed at home within one single week, each month. The logs of unsupervised physical activity and group attendance protocols were matched to ensure sessions were registered only once (<10 occasions). The control group could exercise without any restriction, and both groups (intervention and control groups) received standard of care.

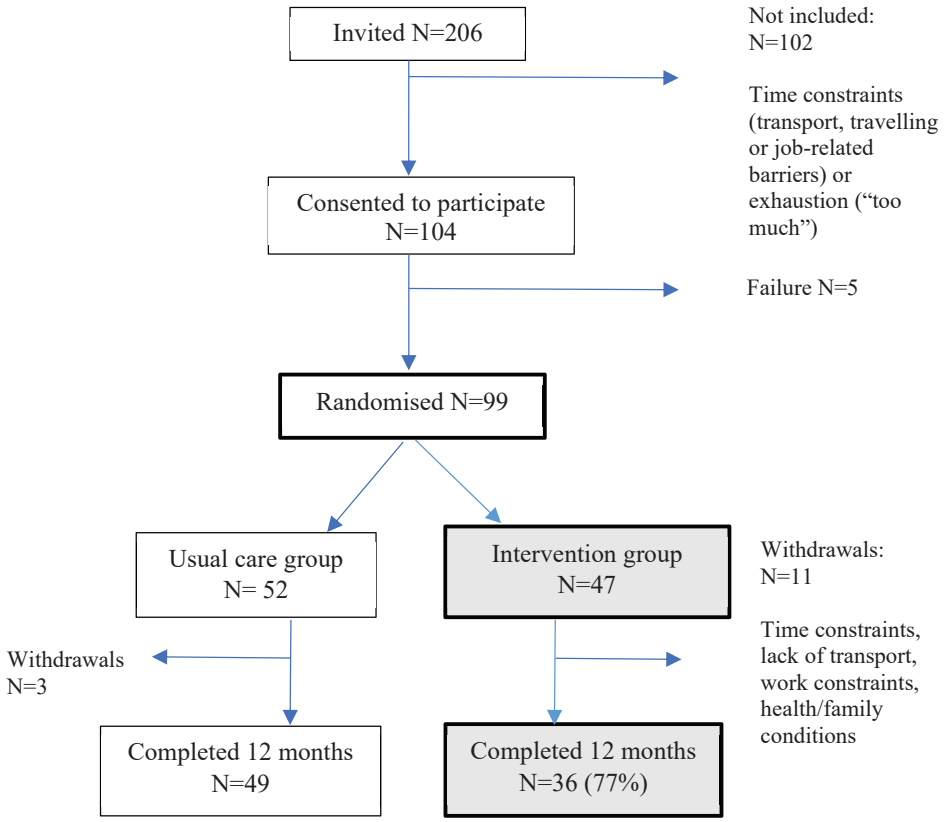

FIGURE 1 FLOWCHART OF PARTICIPANTS THROUGH THE STUDY

Adherence is one of several concepts used in assessing intervention feasibility [38-40], and is observed to be operationalized differently and based on quite different calculation bases across studies [41,42]. In the present paper we prefer to use the term 'adherence', defined by the World Health Organization as "*the extent to which a person's behaviour […] corresponds with agreed recommendations from a health care provider*" [43], and include withdrawals in our analyses.

Assessment of patient characteristics

Individual baseline variables were assessed by means of questionnaire or tests and measured before surgery. *Age* was calculated from the patient's birth date. Height and weight were performed with participants wearing light clothing and no footwear. Height was measured to the nearest 0.5 cm, and weight to the nearest 0.1 kg on an electronic scale. *BMI* was calculated by kg/m^2 by weight and height. *Maximal oxygen consumption* ($\dot{V}O_{2max}$ $ml \times kg^{-1} \times min^{-1}$) were assessed by the same trained personnel using a modified Balke treadmill protocol on a Woodway treadmill (Weil am Rhein, Germany). $\dot{V}O_{2max}$ was calculated as the average of the three highest sequential 10-second intervals and was measured directly at baseline before any treatment and then at 6- and 12 months post-surgery.

Socioeconomic status was measured as *total years of education, highest level of education* (elementary school; vocational training; high school; college/university degree≤4years; university degree>4years; other), or *occupation class* (unskilled; semi-skilled; skilled manual/artisan; other self-employed/farmer/fisherman; non-professional occupation; professional occupation; public/private management position; academic management position) and *household income* (1NOK≈0.1€) (<350.000; 350.000–599.999; 600.000–999.999; ≥1.000.000) (see [44] for details).

Baseline *physical activity* level was measured as *occupational physical activity* (sedentary; a lot of walking; walk and lift; heavy manual) and *total sum of minutes of all reported leisure-time physical activities* during the last 12 months (min/year = min/bout×bouts/week× (months/year×4.3weeks/month). I.e., a woman who for example swam 2-3 times/week, 40 min/bout, 4 months/year, and hiked >4times/week, 60 min/bout, 12 months/year, got a score of 2.5×40×(4×4.3)+4.5×60×(12×4.3)=15652 min/year (261 hours/year). All variables reported by questionnaires were checked by trained study nurses for inconsistencies and participants were interviewed, when necessary. Comorbidity was registered at the baseline interview (as other cancer diseases, categories of cardiovascular diseases, musculoskeletal diseases, respiratory diseases or problems, metabolic diseases, neurological diseases, urological diseases or other problems; as depression) and reported as *total number of comorbidities*.

Breast tumour characteristics and patient treatment

The excised tumours were characterized histologically and immunohistochemically and classified according to TNM, histological type, grade and receptor status, as described in Flote et al. [45]. Axillary lymph nodes status was reported as number of affected and removed lymph nodes and reported as positive (pN+) or negative (pN0) status. In accordance with current national treatment guidelines (www.nbcg.no); dependent on patient and tumour characteristics, chemotherapy was given as anthracycline based chemotherapy as FEC or EC i.e. 5-fluoruracil, F; epirubicine, E;

cyclophosphamide, C; every three weeks four times alone, or followed by 12 weeks of a taxane, weekly paclitaxel/ or 3-weekly docetaxel. The therapy started 4–6 weeks post-surgery and lasted for 12–24 weeks [39], and chemotherapy was endeavoring scheduled to the day after the group exercise in order to reduce its potentially negative effect on the patients' attendance to these sessions. For patients having a HER-2 positive tumour, the first part (4 out of 17) of trastuzumab cycles was given with paclitaxel or docetaxel, and the rest every third week thereafter. Post-surgery daily radiation therapy for 3–5 weeks was started 3–4 week after end of chemotherapy, otherwise 5 weeks post-surgery. Nine patients received intraoperative radiotherapy (IORT) at the time of primary surgery. Endocrine therapy (tamoxifen or an aromatase inhibitor) was started after end of chemotherapy, or 3–4 weeks post-operatively for those who did not need chemotherapy, and endocrine therapy was scheduled for 5–10 years. Zolendronic acid was given every 6 month for 5 years.

Statistical analyses

Adherence to *overall supervised group exercise* was referred as a percentage of full attendance, defined as attending 80 group sessions during 12 months, excluding holidays (such as winter-, Easter-, general staff (summer)- and Christmas holidays). This was considered a reasonable expected number and may be compared with regular schooldays. *Adherence to group exercise over time* was analysed as adherence after each intervention quarter. Because the model used to calculate overall adherence was inapplicable in calculating quarterly adherence, quarterly adherence rates were based on patients' number of attendances each quarter divided by the number of maximum potential exercise sessions during a quarter. In addition, monthly attendances were summarized to detect seasonal variations.

Adherence to unsupervised at-home physical activity was calculated as the average reported minutes/weeks of at least moderate intensity physical activity divided by the corresponding agreed 120 minutes/week. The average minutes/week were calculated by total minutes reported, divided by number of submitted week-logs (i.e. only submitted logs were analysed).

In order to evaluate the impact of missing data caused by patients who did not complete the intervention, adherence rates were reported both with and without withdrawals. Patients who either did not meet at the group exercise sessions or withdrew from the group exercise during the first six months of the intervention period were treated as *withdrawals* (n=11). The remaining patients were treated as *completers* (n=36). Some withdrawals continued the unsupervised physical activity after they withdrew from group exercise sessions.

The relationship between socio-demographic variables and adherence to group exercise and unsupervised physical activity was examined using the Kendall's *tau-b* and the Pearson's r correlation coefficient method for ordinal or scale and

nominal measures, respectively. Normality distribution was tested by the Shapiro-Wilk test, showing significant departure from normality. A Mann-Whitney U test and Kruskal-Wallis' test were employed to examine distribution differences in adherence to group exercise and unsupervised physical activity between groups. Identical analyses were run for the sample *with* (n=47), and the sample *without* withdrawals (n=36). For the Mann-Whitney U test and the Kruskal-Wallis' test, the variables were recoded into two or three groups, respectively. High/low *education* level (≥college degree/<college degree); white-collar/blue-collar *occupation* (self-employed higher-grade professionals, management position in public or private organization, professional occupation/ non-professional occupation, other self-employed, farmer or forester, fisherman, skilled manual worker, artisan, supervisor of manual workers, unskilled manual worker, driver); *income* level (low: ≤599,999NOK/ medium:600,000–999,999NOK/ high:>1,000,000NOK); lower/higher *age* (29–52/53–75); Active/sedentary *occupational physical activity* (heavy manual work, frequently lifting and walking, frequently walking/sedentary); active/sedentary *leisure-time physical activity* (>150 min/week/<150 min/week (on average) during the last 12 months).

The results are presented as aggregated measures at the group level in line with informed consent signed by each study participants to avoid possible patient identification due to small numbers. The level of significance was set at 0.05 (p≤0.05). Holm-Bonferroni-corrections for multiple tests were performed on significant correlations, and Bonferroni-corrections as post-hoc Kruskal Wallis' tests to detect significant differences in mean rank adherence between groups. Omitted data for variables other than adherence were treated as missing and accordingly decreased sample size. SPSS Statistics (v25) was applied for statistical analyses.

Ethical considerations

The present project was conducted according to the Declaration of Helsinki with its consecutive amendments. The proposed project includes an intervention study, and a careful control of the intervention study has taken place (www.clinicaltrials.com NCT02240836). All results have been presented as aggregated measures at group level. All participants signed an informed consent form prior to inclusion in the study. The study was approved by the Regional Committee for Medical Research Ethics (2011/500aEBBA-II/ 2014/945 EBBA-II).

Results

In the present intervention group study, patients were on average 54.2 years at diagnosis, and 30% of the patients had mastectomy. Before surgery, 55% had a college degree or more, 55% had a white-collar occupation, and 28% was in the highest income group. A total of 15% of the participants were smokers. Mean BMI

was 27.8 kg/m^2 and mean $\dot{V}O_{2max}$ was 28,4 ml×kg^{-1}×min^{-1}. On average, the participants reported leisure-time physical activity for close to 3 hours/week (all intensities included) during the preceding year pre-diagnostic. A total of 68% of the patients reported co-occurrences of 2 to 5 other diseases, whereas 38% reported one disease in addition to breast cancer. Endocrine therapy, chemotherapy, trastuzumab and radiotherapy were given to 64, 53, 19 and 77% of the patients, respectively. Furthermore, 26% had tumour size >20mm, 64% have tumour grade I or II, 70% without lymph node involvement, 87% were ER/PgR positive and 23% HER-2 status positive (Table 1).

Withdrawals versus Completers

A total of 149 patients were invited to participate, but 102 of these patients was not able or not interested to participate in our study; transport difficulties, long travel distance >1.5 hours, workplace constraints, and for some too much in combination with treatment. Of the 47 patients who consented to participate and were randomized to the intervention group, there were 11 patients who, at various times after intervention start-up, no longer participated in the group sessions (Figure 3). The reported reasons for withdrawal were lack of time, lack of transport, workplace constraints, or health or family conditions. No withdrawals were due to resection.

Mean age among the *withdrawals* (n=11) was 58 years. A total of 36% had a college degree or more, 54% were in a white-collar position, and 27% was in the highest income group. In the group of withdrawals, 18% were smokers, and pre-trial leisure-time physical activity per week (all intensities included) was reported to be 3.5 hours, on average. Mean BMI was 29.7 kg/m^2, and Vo_{2max} was 24 ml×kg^{-1}×min^{-1}. While 18% had mastectomy, endocrine therapy, chemotherapy, trastuzumab and radiotherapy were given to 36, 36, 27 and 82% of these patients, respectively. The tumour size was >20mm in 27%, and 55% had tumour grade I or II, and 82% without lymph node involvement. Furthermore; 73% were ER/PgR positive and 9% HER-2 status positive (Table 1).

Compared with the group of *completers* (*n*=36), the *withdrawals* as a group appeared to be older, have lower socioeconomic status, higher BMI (kg/m^2), and lower VO_{2max} (ml×kg^{-1}×min^{-1}), despite more minutes in pre-trial leisure-time physical activity: Both the education level and the household income as well as the occupational class were on average lower among *withdrawals* than among *completers*. Chi-square tests of independence showed that the difference was statistically significant only for household income (p=.005). (Table 1). Mann-Whitney U tests indicated that pre-trial leisure-time physical activity level were (non-significantly) higher for *withdrawals* (mean rank=19.9) than for *completers* (mean rank=25) (U=108, p=.269). The baseline BMI (kg/m^2) was (non-significantly) lower

among *withdrawals* (mean rank=22.8) compared to *completers* (mean rank=28) (U=154, p=.279). An independent sample t-test showed a significantly lower VO_{2max} ($ml \times kg^{-1} \times min^{-1}$) in *withdrawals* (M=24.0, SD=7.89) compared to *completers* (M=29.7, SD=5.4); t (45) =-2.69, p=.010 (Table 1). Although there are statistically significant differences between the two groups in endocrine therapy, most patients received *combinations* of breast cancer treatments. Differences in treatment combinations, between *completers* and *withdrawals*, were statistically non-significant (not shown), as were differences in tumour characteristics between the two groups (Table 1).

TABLE 1 BASELINE CHARACTERISTICS OF PATIENTS RANDOMIZED TO EXERCISE INTERVENTION (N=47, N=36 VS N=11)

Patient characteristics at baseline	*All patients, n*= 47 M (SD) or N (%)	*Completers, n*= 36 M (SD) or N (%)	*n* = 36 vs. *n* = 11 *p* value
Age	54.2 (10.1)	53.0 (9.8)	≤55 yrs; >55 yrs: .427[c]
Education			.101[c]
College/university degree > 4 years	12 (25.5)	8 (22.2)	
College/university degree ≤ 4 years	14 (29.8)	14 (33.3)	
High school = 3 years	13 (27.7)	9 (19.4)	
Vocational training/elementary school	8 (17.1)	4 (11.1)	
Occupation			.439[c]
Management position public/private	7 (14.9)	5 (13.9)	
Management position, academic	6 (12.8)	4 (11.1)	
Lower profession	13 (27.7)	11 (30.6)	
Non-professional occupation	10 (21.3)	9 (25.0)	
Self-employed business/skilled, artisan	6 (12.8)	4 (11.1)	
Semi-skilled, unskilled	5 (10.6)	2 (5.6)	
Household income [a]			**.005***[c]
High	13 (27.7)	10 (27.8)	
Medium	17 (36.2)	16 (44.4)	
Low	17 (36.2)	10 (27.8)	
Currently smoking	7 (14.9)		n.a.
Number of comorbidities	1.2 (1.2)	5 (13.9)	n.a.
Occupational physical activity [b]			.909[c]
Sedentary	22 (46.8)	18 (50.0)	
Frequently walking	8 (17.0)	7 (19.4)	
Frequently walking and lifting/heavy	10 (21.2)	8 (22.2)	
Leisure time physical activity (min/year) [b]	8477 (6419)	7710 (5615)	.269[d]
BMI, kg/m^2	27.8 (5.5)	27.3 (5.2)	.279[d]
VO_{2max} $ml \times kg^{-1} \times min^{-1}$	28.4 (6.4)	29.7 (5.4)	**.010***[e]

TABLE 2 (CONTINUED) 3 BASELINE CHARACTERISTICS OF PATIENTS RANDOMIZED TO EXERCISE INTERVENTION (N=47, N=36 VS N=11)

Tumour characteristics	N (%)	N (%)	*p* value
Histology			.674[c]
IC/ILC	44 (93.7)	34 (94.6)	
DCIS /LCIS only	3 (6.4)	2 (5.6)	
Pathologic tumour size, mm			.810[c]
≤10	10 (21.3)	7 (19.4)	
10-20	25 (53.2)	20 (55.6)	
>20	12 (25.5)	9 (25.0)	
Grade			.630[c]
Grade 1	11 (23.4)	8 (22.2)	
Grade 2	19 (40.4)	16 (44.4)	
Grade 3	14 (29.8)	10 (27.8)	
ND, DCIS/ LCIS	3 (6.4)	2 (5.6)	
Lymph node involved			.336[c]
0	33 (70.2)	24 (66.7)	
1-3	13 (27.7)	11 (30.6)	
>3	1 (2.1)	1 (2.8)	
ER/PgR status			.059[c]
Positive	41 (87.2)	33 (91.7)	
Negative	3 (6.4)	1 (2.8)	
ND, DCIS/LCIS	3 (6.4)	2 (5.6)	
HER 2 status			.172[c]
Positive	11 (23.4)	10 (27.8)	
Negative	34 (72.3)	24 (66.7)	
ND, DCIS/ LCIS	2 (4.3)	2 (5.6)	
Treatment	N (%)	N (%)	*p* value
Surgery (mastectomy / BCS)	14 (29.8)/33(70.2)	12 (33.3)/24(66.7)	.336[c]
Endocrine therapy	30 (63.8)	26 (72.2)	**.030***[c]
Chemotherapy	25 (53.2)	21 (58.3)	.201[c]
Trastuzumab	9 (19.1)	9 (25.0)	.065[c]
Radiotherapy	36 (76.6)	27 (75.0)	**.640**[c]
Zolendronic acid	17 (36.2)	14 (38.9)	n.a.

[a] High: NOK≥1.000.000; Medium: NOK 600 000-999 999; Low: NOK <350 000-599 999 [b] Numbers may vary due to missing information

[c]Chi-square test [d]Mann-Withney U-test [e]T-test *Statistically significant, α= 0.05Abbreviations: DCIS, ductal carcinoma in situ; LCIS, lobular carcinoma in situ; ER, estrogen receptor; PgR, progesterone receptor; HER2, human epithelial receptor; IORT, intraoperative radiotherapy; ND, not done; BMI, body mass index (kg/m^2); n.a., not assessed.

Attendance rates and adherence to group exercise and unsupervised physical activity

Mean adherence rate to group exercise sessions was 81% (median= 85.4) among *completers* (*n*=36) and 63% (median=78.8) for the *total intervention group* (*n*=47) (Figure 2). For *completers,* the shortest individual participation period duration from start to finish, independent of adherence rate, was 40 weeks. In the group of *withdrawals* (*n*=11), the longest individual participation period duration was 24 weeks (depicted in Figure 3; orange dots represent attended, and grey dots represent unattended exercise sessions). Variations in total *attendances* to group exercise sessions throughout the seasons of a year, including data from all participants added

up (i.e., the sum of all ongoing intervention periods, from 2014 to 2017) showed that attendance dropped during weeks of holidays: July and August, and December and January had pronounced drops in attendance, April had a minor decline.

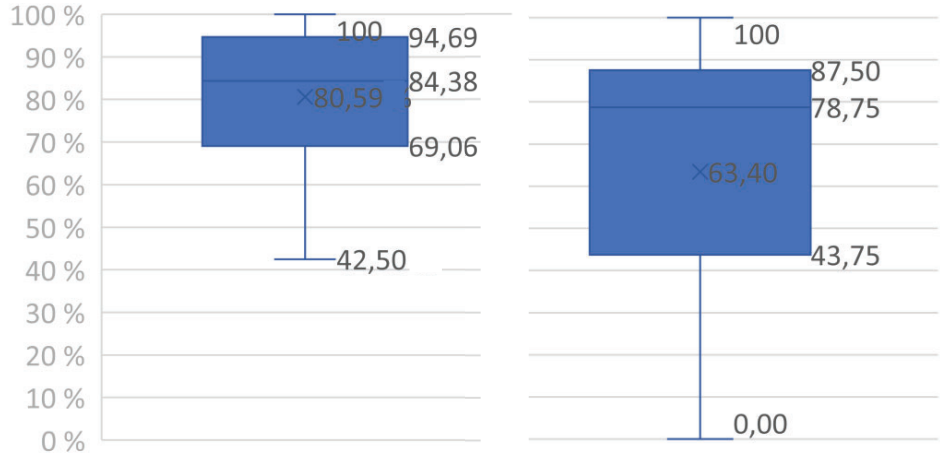

FIGURE 2: TOTAL ATTENDANCE TO GROUP EXERCISE SESSIONS (%). LEFT: EXERCISE GROUP; COMPLETERS (N=36); RIGHT: EXERCISE GROUP; TOTAL (N=47)

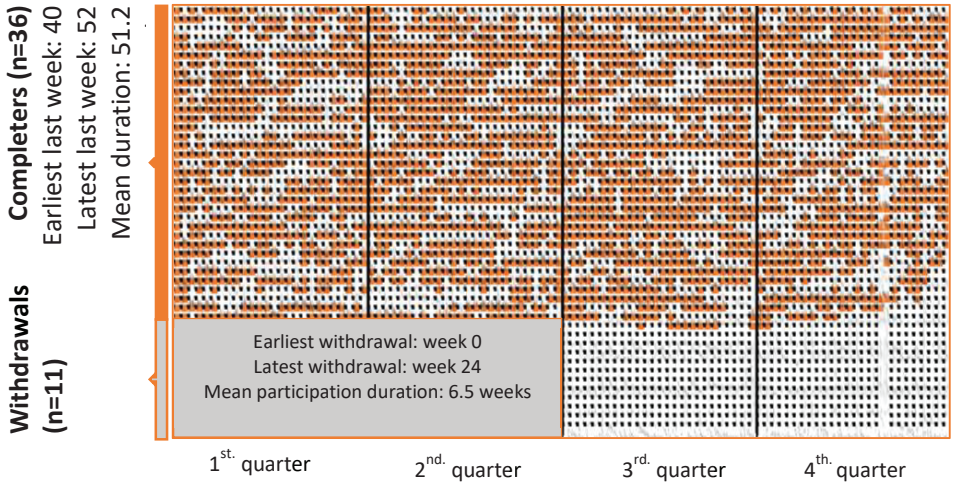

FIGURE 3: PARTICIPATION PERIOD DURATION FROM THE START THROUGH THE LAST GROUP EXERCISE SESSION ATTENDED. ORANGE: COMPLETERS (N=36), GREY FIELD: WITHDRAWALS (N=11)

The highest number of registered attendances was observed in November, whereas fewest attendances were registered in August (not shown). For *completers*, only small differences (60-63%) in mean adherence to group exercise after each quarter, regardless which time of the year the intervention started.

Logs of unsupervised physical activity were fully completed (one 7-days week per month) by 66% (*n*=24) of the *completers* (*n*=36). In this group, the mean adherence to unsupervised physical activity was 230% (SD 213) of 120 min/week of at least moderate intensity, whereas these numbers were 234% (SD 350) for the *total intervention group*.

Associations between adherence and baseline variables

Correlations between adherence and baseline variables are presented in Table 2. No data of socioeconomic status correlated significantly with neither adherence to supervised group exercises at any quarter, nor with adherence to unsupervised at-home physical activity. Among *completers* (*n*=36), age correlated positively with adherence to supervised group exercise after 9 (*r*=.341, p=.042) and 12 months (*r*=.366, p=.028), and with adherence to supervised group exercise relative to 80 group sessions (*r*=.369, p=.027). Age correlated also significantly with unsupervised at-home physical activity (*r*=.356, p=.014) and number of comorbidities showed a weaker negative, but significant correlation with adherence in the first quarter (*r*=-.237, p=0.04) when *withdrawals were included* (*n*=47) in the analyses. However, none of these associations remained significant after Holm-Bonferroni-corrections. In the sample of *completers* (*n*=36), neither VO_{2max} ($ml \times kg^{-1} \times min^{-1}$), BMI ($kg/m^2$) or number of comorbidities correlated significantly with adherence to group exercise at any quarter of the intervention period.

Although weak and non-significant trends; among *completers*, a positive correlation between adherence to group exercise and level of pre-trial leisure-time physical activity in the preceding 12 months, and between adherence to group exercise and type of pre-trial occupational physical activity, decreased from the first through the third intervention quarter. When *withdrawals* were included in the analyses, a similar trend was seen for type of occupational physical activity (higher adherence, more active occupation), however the correlation was weaker and turned negative for leisure-time physical activity.

The *non-parametric tests of distribution differences* in adherence to group exercise and unsupervised physical activity for different baseline variables did not produce any results which could be interpreted as credible evidence of real differences in adherence between groups (Electronic Supplementary Material 1).

TABLE 4 CORRELATIONS BETWEEN SOCIODEMOGRAPHIC AND CLINICAL CHARACTERISTICS OF THE PATIENTS, BY ADHERENCE TO SUPERVISED GROUP EXERCISE PROGRAM (60 MIN X 2/WEEK) - OVERALL, AND STRATIFIED BY FOUR PERIODS (1ST, THE 2ND, THE 3RD AND THE 4TH QUARTER), AND UNSUPERVISED EXERCISE AT HOME.

Variable	*1st quarter*	*2nd quarter*	*3rd quarter*	*4th quarter*	*80 group sessions*	*At-home PA*
Completers in exercise group (n=36)						
[a]*Total years of education*	0.093	-0.036	-0.088	-0.205	-0.195	-0.026
[a]*Occupation class*	-0.026	-0.062	-0.031	0.042	0.067	-0.118
[a]*Household income*	-0.206	-0.179	-0.103	-0.126	-0.106	-0.140
[a]*Occupational activity*	0.226	0.150	0.039	0.090	0.091	-0.026
[a]*Leisure-time physical activity*	0.247	0.158	0.070	0.045	0.059	-0.245
[b]*Age*	0.210	0.236	**0.341***	**0.366***	**0.369***	0.231
[b]*BMI (body weight/body height^2)*	-0.229	-0.236	-0.155	-0.117	-0.085	-0.216
[b]*Baseline VO_{2max}*	-0.259	-0.110	-0.154	-0.052	-0.067	-0.036
[a]*Comorbidities*	-0.168	-0.116	-0.050	0.015	-0.004	-0.051
Withdrawals included (n=47)						
[a]*Total years of education*	0.024	-0.042	-0.054	-0.120	-0.114	-0.094
[a]*Occupation class*	0.051	0.002	-0.020	-0.014	0.027	-0.048
[a]*Household income*	-0.082	-0.036	0.054	0.049	0.061	-0.162
[a]*Occupational activity*	0.245	0.173	0.054	0.081	0.080	-0.028
[a]*Leisure time physical activity*	0.008	-0.078	-0.156	-0.171	-0.159	-0.245
[b]*Age*	-0.143	-0.150	-0.119	-0.109	-0.103	**0.356***
[b]*BMI (body weight/ body height^2)*	-0.098	-0.129	-0.139	-0.148	-0.139	-0.001
[b]*Baseline VO_{2max}*	0.038	0.163	0.226	0.287	0.283	-0.183
[a] *Comorbidities*	**-0.237***	-0.052	-0.207	-0.172	-0.132	-0.143

[a] Tau-b

[b] Pearson's *r*.

*Statistically significant before a Holm-Bonferroni correction, but not after (p>0.05)

Discussion

In the present study, the overall mean adherence to an outdoor supervised group exercise were high, as 81% of the participants managed to fulfil the 12-month exercise intervention. To our knowledge, this is the first study to report adherence to an outdoor exercise program throughout a year with seasonal variations during adjuvant treatment in breast cancer patients. Previous reports from physical activity interventions in breast cancer populations show adherence rates for exercise program ranging from 42–91%, [41], 71–83% [46], and 70–95% [18,24,47-50]. Unfortunately, the comparability between studies is limited, due to inconsistencies in operationalizations and calculations of adherence [41,42], as well as variations in duration and timing of the exercise program during the post-surgery period. However, it has been suggested that adherence rates are lower in cancer populations than in non-cancer populations, as side-effects from chemo- and/or radiation therapy, as well as the mental strain of being severely diagnosed, have been shown to affect cancer patients' attendance to physical activity interventions [51]. In addition, withdrawing from physical activity interventions has been explained by medical complications,

deterioration of medical condition, or personal or social problems, at least in programs with a 6-12 weeks duration [14]. The influence of missing data on reported adherence rates [52] was demonstrated by the fact that the adherence rates increased by 27% when we excluded withdrawals from the analysis. A clearer picture of the overall patient group that is offered the physical activity intervention emerge when rates are reported both with and without data from patients who withdrew from the study intervention.

Adherence and intervention design

The overall group exercise adherence rates after each quarter came out virtually equal, and the trend of attendances was rather stable throughout a year. These results are in contrast to the suggestion that shorter physical activity interventions (3–6 months) are more feasible in terms of adherence rates compared with trials including longer intervention periods (1–2 years) [16]. Basically, besides demonstrating adherence stability, our results indicate that intervention duration may be of less importance in explaining adherence. However, considering the participation periods among withdrawals in our study, which ended in the 24th week, a shorter intervention period may have resulted in higher retention rates.

A feature of our study was the group sessions and the regular and professional support provided by experienced physiotherapists and physicians. As suggested in previous studies [21,53], tailored counselling increases the motivational readiness to adhere to physical exercise guidelines among breast cancer patients burdened with side-effects and medical appointments. Other studies also highlight continuous attention as a crucial factor in physical exercise interventions [54]. Thus, the pre-intervention physical testing, professional presence and follow-up, in addition to the group identification and internal mutual support from exercise group members, may have positively affected the stability in group exercise attendance in our study (Figure 2).

The present study was also designed with outdoor group exercise, which could have made the adherence rates more vulnerable to seasonal variations due to the Nordic climate with rainy days and harsh winters, compared to the invariant indoor exercise conditions applied in most studies previously mentioned. The climate has been suggested to influence on adherence even across indoor training venues, due to a geographical split [55]. Thus, one could have expected lower adherence to the outdoor group exercise in the present study. However, in our study, seasonal attendance variations seem coincide with national standard holiday periods, such as Easter-, general staff (summer)- and Christmas holidays, rather than changing weather conditions. Such finding further supports the effect of professional follow-up and support from other group members, which was suggested above.

Adherence to unsupervised at-home physical activity

Although participants' adherence to supervised exercise could not exceed 100% due to the predefined exercise program, the mean adherence to unsupervised at-home physical activity appeared higher (230%, SD 213). These divergencies are inconsistent with previous studies which report higher adherence in supervised compared to non-supervised physical activity interventions [18]. However, they support the assumption that home-based physical activity interventions are more feasible than scheduled exercise sessions among breast cancer patients (34), also compared to centre based programs in adults >50 years [17]. Nevertheless, the fact that self-reported physical activity are often infested with recall- and response biases [56], which in turn, may result in over-reporting physical activity levels [57], may account the high adherence scores in our self-reported data. The explanation could also be that although the participants in our study were motivated for group exercise, the immediate side-effects from the breast cancer treatment, likely reduced their inclination to engage in these time-set sessions, whereas unsupervised physical activity may have been considered less stressful as it could be carried out within more convenient settings of time and space. A previous study of physical activity among long-term breast cancer survivors identified typical challenges of balancing family duties, breast cancer related fatigue and physical activity [58], and may support such an interpretation. However, the rates of adherence to unsupervised physical activity in our study compare much favourably also to previous exercise trials with unsupervised physical activity, both in healthy samples (14) as well as in breast cancer patient samples [41,59]. That said, 100% adherence to at-home physical activity in our study corresponded to being physically active, of at least moderate intensity, for 120 min/week. The sums of reported min/week were divided by the number of week-logs submitted by each patient. If we had included non-delivered logs in the analysis of at-home physical activity, considering these as zero activity, the average adherence to unsupervised physical activity would have come out as considerably lower. On the other hand, unreported data could of course include at-home physical activity above the average, thus we would have underestimated true physical activity adherence.

Predictors of adherence

Beside reporting adherence rates, our aim was to identify possible predictors of adherence among health and sociodemographic variables. Types of breast cancer treatment and tumour characteristics were not included in these analyses. Nevertheless, which combination of treatment the participants received was examined, however none were associated with completing the intervention in our study. Previous studies have produced diverse results on the association between chemotherapy and adherence [19-21]. The fact that we found no statistical significant

difference between completers and withdrawals as to whether they received chemotherapy or not (Table 1), could be interpreted as to all patients were strongly motivated to do what it takes to be cured, regardless the exhausting treatment.

Age and BMI, VO_{2max}, physical activity levels, and comorbidity

Our analyses of associations between health variables and adherence rendered uncertain findings, however age may have influenced on study participation in two ways. First, the group of withdrawals had higher average BMI (kg/m^2) and reported more pre-trial minutes in leisure-time physical activity compared to completers, but significantly lower levels of VO_{2max} ($ml \times kg^{-1} \times min^{-1}$) (Table 1). The level of VO_{2max} are lower in our population of breast cancer patients than what is considered reference values for a general population of Norwegian women of the same age [60]. However, the fact that the withdrawals also had higher mean age than the whole intervention group, may explain some of the differences in the level of $\dot{V}O_{2max}$ between the groups. In addition, they may also prefer low intensity physical activity, such as walking, before more vigorous physical exercise. Previous studies showing that VO_{2max} has a ten-year year decline of 10% in women [61] and that there may be a progressively increase in BMI with age in women [62], support the interpretation that there may be an interrelationship between age, BMI and VO_{2max} ($ml \times kg^{-1} \times min^{-1}$) in our data.

Secondly, the negative correlation found between comorbidity and adherence, could, if statistically significant, be interpreted as the more diseases, the more difficult it is to be physically active. The Holm-Bonferroni correction that was applied in these analyses, was chosen before the more conservative Bonferroni procedure to address the issues of type 1 error. Although it is better constructed to limit type 2 error compared to the Bonferroni correction, the Holm-Bonferroni approach still reduces the power to detect real effects [63]. Therefore, when the mentioned negative relationship between comorbidity and adherence were found significant before, but not after the Holm-Bonferroni correction (Table 2), it is possible that we may have failed to acknowledge these as real, existing associations, and that the above interpretations were correct. This applies also to the positive age-adherence correlation at 9 and 12 months for the group of completers, which was found significant before, but not after the Holm-Bonferroni correction (Table 2). Therefore, it might be that some age-related factors influence long-term adherence to interventions, such as the one in our study. The fact that the initial negative comorbidity-adherence association turned into a (weak) positive correlation among completers throughout the intervention period, likely also reflects a correlation between age and comorbidity.

The group of participants >55 years, which also included women who had retired from work, had non-significant, but higher, mean rank distribution of adherence to group exercise than did younger participants (Electronic Supplementary

Material 1). Together with the mentioned positive correlation between age and adherence to group exercises at 9 and 12 months, these tendencies may indicate that being younger and probably more rapidly reported fit, and being part of the workforce, reduce adherence to physical activity interventions. So, being older may hinder some patients from participating in general (i.e. probably due to comorbidity), whereas younger participants may have family or work-related duties that influence on attendance stability throughout the intervention period, rendering somewhat lower adherence rates in the lower age-group.

Socioeconomic status

The withdrawals had lower average socioeconomic status, including statistical significantly lower household income, compared to completers (Table 1). These tendencies support results from previous studies examining determinants of physical activity adherence, showing that high adherence to physical activity may be related to higher socioeconomic status [19,24]. The fact that some patients could not afford the transport expenses, had workplace constraints related to group exercise within the working hours, or issues related to having an exemption card for public health services, could partly explain these results. Another expectation could be that as education seems to be positively associated with leisure-time physical activity [64], adherence to physical activity interventions relate to pre-trial physical activity level [65,66].

Based on the above, we tested a possible association between adherence to group exercise and socioeconomic status in our data. We found no evidence for such a relationship, corresponding to other previous reports of adherence to physical exercise among breast cancer patients [67,68]. Usually, such so-called statistically insignificant results are interpreted as there is a lack of credible evidence of real differences in adherence between socioeconomic status groups. Statistical non-significantly differences are therefore perceived as less interesting, and often larger sample sizes are called for. Accordingly, as the sample-size in our study is rather small, such explanations seems reasonable. However, as pointed out in a revived debate in *Nature* and *the BMJ* on the misconceptions of the concept of statistical significance [69,70], a non-significant result is no proof that there is no difference. Rather than concluding with it being uninteresting, an uncertain result should therefore be considered from alternative angles. A dichotomous usage of a p-value could potentially cover up the fact "that some analyses are biased, some false positive results are overhyped, and some genuine effects are overlooked"[71].

An alternative interpretation of our insignificant socioeconomic status results, therefore, is that they relate to sample misrepresentation of socioeconomic status group distributions. A homogenous sample has elsewhere been suggested to explain non-significant socioeconomic status-differences [67]. In our study sample,

55% of all participants held >13 years of education, whereas only 17% had <high school. These numbers diverge from comparable Norwegian statistics of educational levels in equivalent age groups. According to Trewin et al. [72], in 2000–2009, 34% Norwegian women aged 50–69, diagnosed with breast cancer, had ≥13 years of education, whereas 29% had ≤10 years of education. The figures in our study are of course more recent than those from Trewin et al. However, educational statistics from the time of the present study start-up (i.e., 2014) show that all Norwegian women aged 50–59, 35% had higher education, whereas 24% had a school level below upper secondary education. For women aged 60–66, 28% had higher and 21% had basic education. In 2009, which is the year referred to in Trewin et al., 31% of all Norwegian women aged 50–59, and 22% aged 60–66 held higher education, whereas 23% and 26%, respectively, had basic school level [73]. Furthermore, the mean household income level among our patients (Table 1) was above the Norwegian median income level after tax in 2017 (NOK510.000 [74]).

Although the association between higher educational level and risk of breast cancer is evident [30,72,75], the above numbers show that neither is the present study sample representative in terms of socioeconomic status group distribution. Thus, statistical test of differences between socioeconomic status groups would in fact be less valid to the population. Previous evidence shows that individuals with lower socioeconomic status less often participate in research projects compared to individuals with higher socioeconomic status [33,34]. This, in addition to the fact that breast cancer patients in low socioeconomic groups fail to meet inclusion criteria in physical activity studies due to more advanced breast cancer at diagnosis, and that physical activity interventions unfortunately do not fit all social groups [76-78], makes it likely that previous studies of adherence to physical activity interventions as well suffer from sample biases similar to the one identified in the present study. In other words, the lack of statistically significant differences between socioeconomic groups identified in previous analyses may stem from small study samples, and, not to the least, that any subdivisions of high and low socioeconomic status are erroneous in terms of group characteristics. Unfortunately, because many articles lack information on sociodemographic distributions within the study samples, representativeness in terms of socioeconomic status is often difficult to decide [79].

Although it is highly probable that differences in data distribution between groups in our study appeared by chance (Electronic Supplementary Material 1), and despite the challenges of representativeness discussed above, one could speculate whether the tendency that high socioeconomic status groups had higher mean rank distribution of attendance to group exercise in the early quarterly compared to later phases might relate to the likelihood of returning to work after breast cancer. Return to work is previously reported to be associated with high education and higher income level [80]. On the other hand, in addition to being statistically non-significant, such

changes in bivariate associations over time may reflect the phenomenon of 'regression toward the mean' [81], rather than real changes in adherence over time.

Strengths and limitations

The long intervention, which is succeeded by a long follow-up period, is expected to yield important knowledge on the effect of physical activity on many aspects of breast cancer patients' health in the long run. In addition, the intervention trial on which our adherence data are based shows several strengths. Firstly, the intervention was provided as an easily accessible service at low costs, as it was conducted in natural outdoors settings, without equipment requirements other than training shoes and comfortable clothing, paid physiotherapists and equipment given to the participants (a jacket, walking poles, and a heart rate monitor watch (actigraph)). Along with the fact that the intervention was completed along with current clinical practice, this speaks to a possible rapid and uncomplicated implementation of an additional treatment pathway including physical activity. Second, the patients were assured the opportunity to participate in secure and trustworthy exercise settings, as the groups were led by trained physiotherapists and regularly visited by physicians available for questions and information. In addition, the small exercise group size made individual adaptations possible, possibly entailing advantageous groups dynamics. It is reasonable to believe that these factors had a positive impact on the ability to accomplish the types and doses of physical activity necessary to achieve the intended effect. To that end, we may add the comprehensive monitoring of the participating patients' unsupervised physical activities.

The study also has some limitations. First, the small sample size reduced the ability to determine statistical significance between groups. Second, from the low-cost indicated above, it follows that the patients had to bear the time to travel and costs of transport hampering remotely living patients from participating. Third, we cannot rule out the possibility that a selection bias occurred because the participants were asked to join an exercise study, which may have excluded patients with low pre-trial leisure-time physical activity levels. On the other hand, all eligible patients who were diagnosed during the study period were invited to participate, hence reducing the risk of selection bias. Fourth, because some patients had challenges in handling their heart rate monitor watches, exercise intensity during outdoor exercise was not reported in the present study. However, the intervention protocol required a certain exercise intensity, thus the lack of specific intensity data was not decisive. Nevertheless, treadmill tests of VO_{2max} ($ml \times kg^{-1} \times min^{-1}$) were applied in order to measure the patients' fitness and thus evaluate the effect of the physical activity intervention in the main study.

Conclusion

In the present study, the adherence to an outdoor tailored supervised 12-month group exercise, and to unsupervised home-based physical activity during adjuvant treatment, was high. Our results support, but also extend previous studies, as our study include outdoor exercise and the adherence rates were equal among those who received chemotherapy compared to those who did not receive chemotherapy. Adherence differences in our study seem to relate to age.

A small sample size, and a typical sample homogeneity on the expense of patients with lower socioeconomic status challenges socioeconomic status group analyses of adherence rates. Unfortunately, such common issues could act as impediments in our aim of identifying groups of patients to whom we need to accommodate our physical activity interventions. In addition, the fact that exercise sessions were conducted during working hours, may have restrained intervention adherence. Although our results are unclear; to suffer high comorbidity, being less fit, and having troubles managing the increased costs involved, or being occupied by paid work, seem to be factors which should be considered in future treatment plans involving physical activity. Physical activity during adjuvant breast cancer treatment may improve health outcomes and better overall survival in breast cancer patients. Further and larger studies are therefore needed to confirm the barriers to physical activity interventions among breast cancer patients suggested in our study, and to explore others.

Conflict of interest disclosures

There are no conflicts of interest.

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ELECTRONIC SUPPLEMENTARY MATERIAL 1: MEAN RANK ADHERENCE TO GROUP EXERCISE AFTER THE 1ST , AFTER THE 2ND , AFTER THE 3RD, AND AFTER THE 4TH INTERVENTION QUARTER (N=36 AND N=47). H- AND U-STATISTICS FOR MANN-WHITNEY U- AND KRUSKAL WALLIS' TESTS, RESPECTIVELY. (P-VALUE).

Variable	*n*	1st quarter mean rank	1st quarter U/H p value	2nd quarter mean rank	2nd quarter U/H p value	3rd quarter mean rank	3rd quarter U/H p value	4th quarter mean rank	4th quarter U/H p value
Education (n=36)									
<College degree	14	17.32	170.5	17.93	162	19.25	143.5	20.50	126
≥College degree	22	19.25	(0.59)[a]	18.86	(0.81)[a]	18.02	(0.73)[a]	17.23	(0.37)[a]
Education (n=47)									
<College degree	21	22.19	311	22.21	310.5	22.57	303	23.33	287
≥College degree	26	25.46	(0.41)[a]	25.44	(0.42)[a]	25.15	(0.52)[a]	24.54	(0.76)[a]
Occupation (n=36)									
Blue-collar	15	16.17	122.5	16.0	120	16.53	128	17.47	142
White-collar	20	19.38	(0.36)[a]	19.5	(0.33)[a]	19.10	(0.47)[a]	18.40	(0.80)[a]
Occupation (n=47)									
Blue-collar	19	21.97	227.5	21.79	224.0	22.16	231	23.08	245
White-collar	26	23.75	(0.65)[a]	23.88	(0.59)[a]	23.62	(0.71)[a]	22.89	(0.96)[a]
Income (n=36)									
Low	10	21.65	2.342	22.00	1.695	21.65	1.424	22.30	1.956
Medium	16	18.97	(0.31)[b]	17.81	(0.42)[b]	16.59	(0.49)[b]	16.41	(0.37)[b]
High	10	14.60		16.10		18.40		18.05	
Income (n=47)									
Low	17	24.15	2.165	23.71	1.211	22.56	0.560	22.74	0.526
Medium	17	27.12	(0.33)[b]	26.56	(0.54)[b]	25.94	(0.75)[b]	25.91	(0.76)[b]
High	13	19.73		21.04		23.35		23.15	
Age (n=36)									
≤55years	19	16.50	199.5	16.97	190.5	15.87	211.5	15.50	218.5
>55 years	17	20.74	(0.23)[a]	20.21	(0.36)[a]	21.44	(0.11)[a]	21.85	(0.07)[a]
Age (n=47)									
≤55years	23	24.61	262	24.89	255.5	23.61	285	23.26	293
>55 years	24	23.42	(0.76)[a]	23.15	(0.66)[a]	24.38	(0.85)[a]	24.71	(0.72)[a]
OPA-level[c] (n=36)									
Active	15	19.67	175.0	18.33	155.0	16.93	134	17.93	149
Sedentary	18	14.78	(0.15)[a]	15.89	(0.48)[a]	17.06	(0.98)[a]	16.22	(0.63)[a]
OPA-level[c] (n=47)									
Active	18	23.97	206.5	22.61	236	20.92	205.5	21.64	218.5
Sedentary	22	17.66	(0.08)[a]	18.71	(0.31)[a]	20.16	(0.84)[a]	19.57	(0.58)[a]
LTPA-level[d] (n=36)									
>150 min/week	13	20.08	170	19.15	158	17.88	141.5	17.08	131
<150 min/week	19	14.05	(0.77)[a]	14.68	(0.19)[a]	15.55	(0.49)[a]	16.11	(0.77)[a]
LTPA-level[d] (n=47)									
>150 min/week	18	22.22	229	21.42	214.5	20.86	204.5	20.31	194.5
<150 min/week	23	20.04	(0.56)[a]	20.67	(0.84)[a]	21.11	(0.94)[a]	21.54	(0.74)[a]

[a] Mann-Whitney U test
[b] Kruskal Wallis' test
[c] Level of daily occupational physical activity (OPA)
[d] Minutes of leisure-time physical activity (LTPA)/week, on average, during the last 12 months

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