UNIVERSITY OF AGDER

Can cycling with an E-bike improve fitness?

Effect of access to an Electric Assisted Bicycle on cycling distance and cardiopulmonary fitness in inactive Norwegian adults.

Lena H. Malnes

Supervisors:

Sveinung Berntsen

Elling Bere

University of Agder, 2016

Faculty of Health and Sport Science

Department of Public Health, Sport and Nutrition

Abstract

Background:

The aims of the present study were to assess the effect of an eight-month intervention with access to an Electric assisted bicycle (E-bike) on (1) the amount of E-biking, (2) changes in cardiopulmonary fitness and (3) to assess whether cycled distance was associated with changes in cardiopulmonary fitness, among inactive adults.

Methods:

Twenty-five inactive Norwegian adults (33 – 57 years of age, 72 % women), were recruited through convenience sampling. Participants were given an E-bike for eight (N = 23) or three (N = 2) months. Socio-demographic characteristics were reported with a questionnaire. Bicycle use was measured with a GPS bicycle computer and cardiopulmonary fitness were measured as maximal oxygen uptake (VO_2 max), before and after the intervention, using a modified Balke protocol to exhaustion.

Results:

During the intervention, cycled distance was 37.6 ± 24 kilometres per week. Participants cycled significantly ($P < 0.001$) more on weekdays (7.1 km/day) compared to weekend days (0.9 km/day). An improvement in VO_2 max (7.7 %, $P < 0.001$) from baseline to post test were associated with cycling distance ($r = 0.49$, $P = 0.042$). Stratified by cardiopulmonary fitness status at baseline, participants with lower fitness had a significant increase in VO_2 max (9.6 %, $P < 0.001$) than participants with higher fitness (1.5 %, $P = 0.626$).

Discussion:

Access to an E-bike for eight months resulted in weekly 37.6 km of cycling which was positively associated with average 7.7 % improvements in VO_2 max. E-bikes may contribute to mobilize inactive individuals to initiate transport-related physical activity.

Keywords

Active commuting, electric assisted bicycle, cycling distance, GPS, maximal oxygen uptake.

Sammendrag

Bakgrunn:

Hensikten med denne studien var å undersøke effekten av en intervensjon, som var å gi tilgang til en Elektrisk sykkel (ELsykkel) i åtte måneder, på (1) mengde ELsykling, (2) endringer i kardiorespiratorisk form og (3) om ELsykling var assosiert med endringer i kardiorespiratorisk form, hos inaktive norske voksne.

Metode:

Et bekvemmelighetsutvalg bestående av 25 inaktive norske voksne (33 – 57 år, 72 % kvinner), fikk disponere en ELsykkel i åtte (N = 23) eller tre (N = 2) måneder. Sosio-demografiske karakteristikker ble kartlagt i et spørreskjema. Sykkelbruk ble målt med en GPS-basert sykkelcomputer og kardiorespiratorisk form ble mål som maksimalt oksygen opptak (VO_2 maks) under en maksimal tredemølletest til utmattelse, før og etter intervensjonen, med en modifisert Balke protokoll.

Resultater:

I løpet av intervensjonen syklet deltakerne 37,6 ± 24 kilometer per uke. Deltakerne syklet signifikant ($P < 0,001$) lengre på hverdagene (7,1 km/dag) enn i helgene (0,9 km/dag). Forbedringene i VO_2 maks (7,7 %, $P < 0,001$) fra pre-test til post-test var assosiert med syklet distanse ($r = 0,49$, $P = 0,042$). Utvalget ble delt basert på kondisjon fra pretesten og det ble observert signifikant forbedring i VO_2 maks hos deltakere med lav kondisjon (9,6 %. $P < 0,001$), men ikke hos deltakere med høy kondisjon (1,5 %. $P = 0,626$).

Konklusjon:

Tilgang til en ELsykkel i åtte måneder resulterte i 37,6 km ukentlig sykling, som var positivt assosiert med i gjennomsnitt 7,7 % forbedring i VO_2 maks. ELsykler kan bidra til å mobilisere inaktive voksne i å innlede transport-relatert fysisk aktivitet.

Nøkkelord

Aktiv transport, elektrisk sykkel, syklet distanse, GPS, maksimalt oksygen opptak

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1.0 Introduction

Transport-related physical activity, also referred to as active travel, may have a protective effect against non-communicable disease and mortality [66, 131] and the potential to improve cardiopulmonary fitness in healthy adults [2, 38, 72, 115]. In addition, a positive association between active travel and reaching the current recommendations for physical activity [13, 48, 84] have been documented. Promotion of active travel can have several advantages. For instance, daily traveling involves most individuals, travel behaviour is repetitive, thus may easily become a habit and active travel might increase the total physical activity level [55, 130, 132]. Unfortunately, the majority of populations in European countries use motorized transport [11, 94].

The promotion of active travel has mainly included walking and cycling with conventional bicycles, although few have considered E-bikes as an alternative. Because individuals can achieve higher velocity with less relative intensity of physical activity when cycling on an E-bike compared to cycling on a conventional bicycle [61, 145, 153], the E-bike may offer extended possibilities. For instance, some have suggested that the E-bike may offer the potential to overcome barriers to initiate cycling [41], such as long travel distances, hilly routes or physical effort [95], thus may lead to increased bicycle use. In fact, Fyhri and Fearnley found that giving access to an E-bike resulted in a 20 % increase in bicycle use corresponding to a total cycled distance of 65 kilometres per week, in which entailed increased frequency of trips, longer cycled distances and increased percentage of cyclists, compared to a control group [58]. According to a conference preceding by Cairns et al., [28] British adults cycled between 24 - 32 kilometres per day, when provided with an E-bike for three months. After these three months, 75 % of the sample reported that they would cycle to work if an E-bike were available. Although, these studies are encouraging, they all rely on self-reported measurements of travelled distances, which have shown to be prone to several estimation errors, such as rounding of numbers [164], subjective perceptions of distances [87, 124, 146] and recall bias [87]. Therefore, as suggested by others [87], findings from self-reported measurements must be interpreted with caution.

Cycling on an E-bike can be defined as a physical activity of moderate intensity [61, 101, 144, 145, 153]. Because previous research have shown that moderate intensity of physical activity are sufficient to increase cardiopulmonary fitness [69], E-biking might have the potential to improve fitness. However, in a study conducted by Geus and colleges, no significant improvements in VO_2 max were observed, after six weeks of cycling an average 15.5 km/day. To the authors knowledge, there are currently no other published intervention studies investigating the association between E-biking and VO_2 max, in which illustrates the need for more intervention studies on this topic.

The aims of the present study were to assess the effect on an eight-month pilot intervention with access to an E-bike on (1) the amount of E-biking, (2) changes in cardiopulmonary fitness and (3) whether cycled distance was associated with changes in cardiopulmonary fitness, among inactive adults.

2.0 Theoretical background

2.1 Physical activity: The human need for bodily movement

The term physical activity have been defined as any bodily movements that require an energy expenditure above resting level [29]. Intensity of physical activity can be expressed as metabolic equivalent of tasks (METs) and categorised as sedentary defined as <1.6 METs, light as 1.6 – 3 METs, moderate as 3 – 6 METs and vigorous as 6 and above [117]. Inactivity however, refers most often to less physical activity than the minimum recommended level [69], although other definitions have been used [119]. The Norwegian Health Directorate's [71] and World Health Organization's [167] recommendations for physical activity is to date, 150 minutes of moderate intensity or 75 minutes of vigorous intensity per week, or a combination of both, performed in bouts of at least ten minutes or more. The American Colleges of Sport Medicine [69] also recommends frequency of physical activity specified as; at least 30 minutes of moderate intensity in five days a week or vigorous intensity for 20 minutes in three days per week.

The positive association between physical activity and health has been known for decades. In the 1950s, Morris and colleges observed an association between occupations involving low physical activity and poor cardiovascular health as well as mortality in the United States [113]. Since then, research has offered strong evidence that physical activity has a protective effect against all-cause mortality [133, 161, 162] cardiovascular disease [161, 162], stroke [162], obesity [140], type-2 diabetes [125, 162], low bone density, bone fractures [162] and cognitive decline and dementia [18]. Physical activity have also been associated with risk reduction in several cancer diseases such as lung cancer [25, 98], pancreatic cancer [12], breast cancer [162, 170], colon cancer [24, 162] and endometrial cancer in postmenopausal women [136]. Others have reported benefits with respect to better quality of life [16] and sleeping quality [92]. Furthermore, as will be discussed in the next section, physical activity may improve cardiopulmonary fitness [3, 99], which in turn have shown a protective effect against several non-communicable diseases [90, 98, 162, 174] and mortality [8, 78, 90, 133, 161]. A recent study by Högström et al. [78] measured cardiopulmonary fitness in 1.3 million Swedish men and observed a 31 % risk reduction in early death, when comparing fit and unfit subjects. Even improvements corresponding to 1 MET in cardiopulmonary fitness have shown a significant risk reduction by 12-13 % in all-cause mortality [90, 98], 6 % cancer incidence [98] and 15 % in cardiovascular events [90]. According to a review of Lee et al., biological mechanisms for this risk reduction might be explained by improvements in insulin sensitively, reduction in blood concentrations of total cholesterol, low-density lipoprotein and triglycerides, more preferable blood pressure, improved autonomic nervous system and lower abdominal obesity and -weight gain [99]. Cardiopulmonary fitness has even been found to be a stronger predictor for mortality, than other well-known risk factors such as smoking, diabetes, hypertension [114] and obesity [8]. Supporting this, Warburton and colleagues found in their review that cardiopulmonary fitness presented a greater risk reduction than physical activity for mortality, insidence of stroke, hypertension and cardiovascular disease [162] although, several studies only included self-reported measures of physical activity.

Unfortunately, most individuals in developed countries live an inactive lifestyle. Estimates have indicated that one third of the world population live an inactive lifestyle based on self-reported physical activity [65]. Hansen et al. [67] measured physical activity with an accelerometer in population based study in Norway and observed that only 20 % of adults were physically active on average 30 minutes per day, according to the current recommendations of physical activity [67]. A study in Canada indicated that 15 % participated in 150 minutes moderate to vigorous physical activity per week [32]. Although, when defining the achievement of recommendations as; at least 30 minutes per day for at least 5 out of 7 days, only 5 % were sufficiently active in Canada [32], 3.5 % in the United States [155] and 1 % in Sweden [64], indicating that level of physical activity are critically low in several nations. As a consequence, inactivity has become a major public health challenge [91] and been identified as the fourth leading risk factor for mortality in high and middle income countries [168].

2.2 Effect of regular physical activity on cardiopulmonary fitness

Since the 1980s, it has been a distinction between health-related fitness and performance related fitness. Health-related fitness typically include four elements; body composition, flexibility, muscle strength and cardiopulmonary fitness [158]. Cardiopulmonary fitness have, by some health professionals, been considered as the most important component of the health related fitness aspect [116] which have been defined as a set of characteristics a person holds, that relates to the ability to perform physical activity for prolonged periods [1, 44, 85].

Non-modifying factors that influence cardiopulmonary fitness in adults are genes, gender and age. A metaanalysis of healthy adult men found that 75 % of the variation in fitness could be attributed to age [163]. Research have indicated that after twenty years of age, cardiopulmonary fitness is reduced by 7 – 10 % per decade [46, 53, 86, 163], with a larger decline in men and younger age groups [86]. Metaanalysis have indicated that the rate of age related declined may be higher in physically active women compared to inactive women [53], although this pattern were not observed in men [163]. In general, men have a higher cardiopulmonary fitness than women [46, 86, 100]. Loe et al. observed a gender difference of 18.7 % in Norwegian adults [100] and 27.0 % have been observed in Americans [86], which is, according to Lee and colleges, [99] due to lower muscle mass, hemoglobin concentration and stroke volume in women compared to men. In addition, biological genes have been identified as inherent factors that may explain 49 – 72 % of the individual variations, which may affect cardiopulmonary fitness at baseline and adaption to physical activity [23, 137].

Known lifestyle factors positively associated with cardiopulmonary fitness are physical activity [3, 97, 99] and dietary intake of carbohydrates [97], while obesity [97, 160] and bed rest [108] have shown inverse associations. In fact, McGuire et al. found that bed rest for three weeks in five, 20 year old men, resulted in a larger decline in cardiopulmonary fitness, than thirty years of aging [108].

Endurance exercise is often considered as a primary source to accomplish improvements in cardiopulmonary fitness [116]; however, non-exercise physical activity, such as occupational physical activity [151], walking [2, 19] and bicycling for transport [37, 38, 72, 115] have also found to be associated with improvements in fitness. In addition, a study by Ross and McGuire indicated that incidental physical activity that occurs sporadically during the day was positively associated with cardio pulmonary fitness in 135 overweight inactive adults [128].

Research comparing multiple bouts of ten minutes spread out during the day and a single continuous session of physical activity have shown similar results in improvements in cardiopulmonary fitness [40, 80, 104]. Interestingly, Jakicic and co-workers [80] also found that multiple bouts of physical activity during the day might be easier to maintain, in overweight women. More specifically, the group who were prescribed multiple bouts had more active days and a tendency of longer total duration of physical activity, compared to a group who were prescribed a single long bout per day [80].

2.2.1 Measures of cardiopulmonary fitness

Maximal oxygen uptake (VO_2 max) is the most recognized measurement of cardiopulmonary fitness [1, 143]. The concept of VO_2 max originated from the work of Archibald Vivian Hill [74] in 1923, who demonstrated that oxygen uptake (VO_2) reaches a maximum due to limitations in respiration and circulation system.

In laboratory or field testing, VO_2 max can be estimated indirectly, for example by measuring heart rate, time to complete a specific test [68], time to exhaustion during a specific protocol [17, 99] or at submaximal workloads using predicting equations corresponding to different protocols [1]. Nevertheless, the most valid and a highly reproducible measure of VO_2 max is thought to be with direct measurements, using indirect calorimetry on maximal workloads [158].

Graded exercise testing have been most commonly performed on a motorized treadmill or a cycle ergometer [106]. The treadmill have shown to produce the highest results [9, 27, 36, 107, 158] and may be more appropriate when measuring health related cardiopulmonary fitness. In particular, studies have found 6.6 – 10.0% higher VO_2 max on a treadmill compared to a cycle ergometer [36, 107, 143]. The differences in testing modes might vary with adaptions to specific training; however, even in well-trained triathlon- and cyclists athletes VO_2 max were significantly higher (6.0 % and 2.8 %, respectively) on the treadmill versus cycle ergometer [9]. Furthermore, protocols on the treadmill consist of either running or walking. The Balke protocol is a widely used [44] walking test lasting on average 25 minutes [7, 107], which is longer than running protocols, typically lasting 6 - 12 minutes [50, 107]. McArdle and colleges [107] found the Balke protocol produced average 6.6 % higher VO_2 max than cycle ergometer protocol; however, they also found a roughly 4.0 % lower VO_2 max than continuous running protocols. The lower VO_2 max might be explained by pain in the lower back due to an inclination above 20 % [107], or as a result of prolonged test duration [27]. The optimal protocols lead to exhaustion in between 8 to 12 minutes from the start of the increments [27]. This might be some of the reasons why there exist numerous modifications of the original Balke protocol [85].

Oxygen uptake follows a linear curve with increasing workload, although at high workloads the slope of the curve decreases a bit or flattens out as anaerobic metabolism does a greater part of the work [6] also referred to as a VO_2 plateau. Achievement of a VO_2 plateau have traditionally been used as the primary criteria for achievement of VO_2 max [10, 77, 112] and may be defined as no further increase than 2 ml/kg/min in VO_2 despite increasing workloads [77, 143]. On the other hand, not everyone achieves a VO_2 plateau [45, 77] and it has been suggested that if the test subject fail to demonstrate a plateau, the term VO_2 max should be replace as VO_2 peak, which represents the highest value during a specific test. However, many researchers accept that the true VO_2 max is reached if two or more secondary criteria are met [106]. Frequently used criteria for assessing maximal exertion have been; an elevated respiratory exchange ratio (RER), achieving a certain proportion of age predicted maximal heart rate (220-age), elevated blood lactate [112] and perceived ratings of exertion [45, 100]. A review of studies published in 2005 and 2006, found major differences in how these criteria are determined. For instance; criteria of peak RER ranged from 1.05 - 1.20, age predicted maximal heart rate from > 85 – 100 % and blood lactate level ranged between 6 - 10 mmol/L [112]. Furthermore, Edvardsen et al found that only 42% achieved a VO_2 plateau, which were not a predictor for the level of VO_2 max [45]. Along with much criticism and discussion of the currently used criteria [10, 45, 112], there exists no general agreement on which criteria are the most valid and which cut off values should be set. Considering the large variety of individual differences in parameters, the most important criteria might be the test leader's observations and subjective assessment of exhaustion of the subject being tested, which have also been used as a primary criteria [4].

2.3 Arenas of physical activity

Physical activity can take place in a variety of settings, for instance during leisure time, during transportation, during working hours or during household chores [168]. Historically, the amount of physical activity in the different domains have changed over time [21, 34]. From ancient years, humans were bound to be physically active in order to gather food for life support [34]. Conversely, in most industrialized countries today, humans have access to food and transportation without the obligatory physical activity, due to advanced technologies and social organisation [34], therefore, physical activity seem to be of a more voluntary nature [142]. Looking at the past thirty years, Borodulin et al. observed an increase in physical activity during leisure time in Finish adults. In contrast, the findings showed a reduction in occupational- and transport-related physical activity in the same period [21]. Other studies have reported similar trends of increased leisure time physical activity [89], while occupational activity have been declined [31, 89]. Tudor-Locke observed in over thirty thousand U.S. adults that 80 % worked in sedentary or light physically active occupations, defined as MET < 3. During a weekday, the findings illustrated that 63 % of the time were spent sleeping and working [157], thus indicating that leisure- and commuting time is essential for the overall physical activity level. Furthermore, low occupational physical activity have been associated with lower physical activity during transportation [94] and greater time spent being sedentary outside of work [157]. Regarding leisure time physical activity, it does not seem to be influenced by transport-related physical activity [55, 130] and have been suggested to be additional rather than a substitute for leisure time physical activity.

In the past decades, there has been an increasing focus on promoting transport related physical activity (herby referred to as active travel) as a way to incorporate physical activity into daily routine [47]. Several studies have indicated that initiating active travel can increase the total physical activity level [130, 132, 154]. In a longitudinal study, Sahlqvist and colleagues [130] investigated changes in active travel and total physical activity. The findings indicated a dose-response relationship between time spent in active travel and total physical activity level, over a 1-year period [130]. In addition, a positive association between engaging in active travel and recreational physical activity have been observed [109, 152]. Menai et al. found that cycling for commuting purposes were associated with leisure time cycling and using a bicycle for other errands [109].

Apart from Denmark and the Netherlands [11], walking for transport have been more common than cycling [11, 19, 75, 132, 159], although cycling may involve greater intensity of physical activity [35]. Costa et al. measured heart rate and movements with an accelerometer during 182 trips with different modes of transportation and found a moderate intensity of walked trips and vigorous intensity of cycled trips, corresponding to 4.6 and 6.4 METs, respectively. By contrast, driving a car or using public transportation, might be categorised as sedentary and light physical activity, as mean intensity were 1.2 METs and 1.6 METs, respectively. Even when combining active travel with motorized transport, for example by cycling to a bus transit, only 20 % of the time were spent in moderate to vigorous intensity [35]. In other words, active travel can be essential in order to achieve the recommended physical activity level. However, a minority of the population in industrial countries initiates active travel [11, 75]. Only 15 % of Norwegian adults use walking or cycling as mode of transport, according to a national transportation survey [75]. Bassett et al. compared national surveys in 17 industrial countries and found Switzerland with the greatest prevalence of 50 %, followed by Netherland of 47 % and Australia with lowest prevalence of 6 % of trips were made by walking and cycling, including all age groups [11].

Many intervention studies aiming to increase cycling activity have shown limited effect. In a review examining the effect of interventions to promote cycling, six intervention studies showed a slightly increase (3.4 percent) in the proportion of bicycle trips at population level. Furthermore, the review found that in 16 interventions aimed to promote environmentally friendly modes of transport, only eight additional bicycle trips per person per year were found [172]. As suggested by Yang et al. [172] a possible explanation for the inefficiency of interventions promoting cycling on population level may be that these interventions mostly appeal to individuals who already initiate cycling activity. Furthermore, Shephard [141] emphasized that there is a need for more efficient methods to involve the most inactive individuals.

2.4 Factors determining active travel

Identifying characteristics of the target group and the factors that influence behavioural change are of high importance in intervention studies [76]. Several characteristics distinguish those who use active transportation and those who do not. For example, travellers by motorized mode of transport (car/moped/buss) are more likely to live further away from the workplace [48], live in rural areas [129, 152, 173], have a higher income [19, 94, 171, 173], and work full time [19, 20, 48] as well as being inactive [111, 154] compared to active travellers. An increased likelihood of a higher income among individuals who use motorized mode of transport, may be seen in relation to owning a car [51] or free parking [109, 111] which also have shown to be negative predictors to initiate active travel modes. Research have indicated that children and adolescents are more likely to use active transport than the adult population [173]. In adults, an inverse association to age have been observed [20, 51] although others reported no significant influence by age [48]. Also, women might have a greater likelihood for active travel than men [173]; however, less likely to transport by bicycle [48].

An important factor for active travel is season of the year, as more people use active transport in summer compared to the winter season [159, 173] with cycling being more sensitive to seasonal variations [159]. Other influential factors are travel time [48, 154, 159] and distance [48, 84, 126, 129, 156], which may be seen in relation to time constrains as being often reported as barrier to walking or cycling [48, 159]. Also, hilly terrain [126], physical discomfort [154] and being sweaty when arriving at the travel destination [48] were negatively associated with active travel. Moreover, individuals who perceived cycling as an impractical mode of transportation were less likely to engage in commuter cycling [154]. As mentioned, only 5 percent of all trips in Norway are performed with a bicycle, even though 75% own a bicycle [75], which indicates that an available conventional bicycle may not be associated with cycling for transport.

Increased awareness of the barriers that affect active travel is important to assess whether the intervention is appropriate for the target population and whether it has the ability to increase self-efficacy. In fact, self-efficacy have been identified as a strong predictor for initiating active traveling [20, 156] illustrating the self-efficacy as a determinant that future interventions should attempt to modify.

As will be discussed in the next section, cycling on an Electric Assisted Bicycle (E-bike) may higher speed with less intensity compared to cycling on a conventional bicycle. Therefore, some have suggested that the E-bike might have the potential to solve common barriers [52], such as travel distance, hills or physical effort [95]. In two qualitative studies consisted of a total of 55 interviews, the findings indicated that the E-bike owners experienced an increased speed with less effort, less sweaty when arriving the destination, reduced travel time [41, 123] and the ability to climb hills with less effort [41] as advantages compared to a conventional bicycle. On the other hand, increased risk of theft [41, 123], stigma from non-users who perceived E-bike as cheating because it requires less effort and the heavy weight of an E-bike [41] were mentioned as disadvantages. Compared to cars, the E-bike owners experienced fresh air and physical activity as advantages. However, lower velocity, increased travel time, limited range and exposure to poor weather were noted as disadvantages compared to driving [123]. Furthermore, evidence have indicated that E-bikes may be highly used for commuting purposes [5, 41, 58, 123].

2.5 The E-bike

In broad terms, the E-bike can be defined as a bicycle with an electric engine and further categorized into two types, a throttle-assisted electric bicycle and a pedal-assisted bicycle. The throttle-assisted bicycle has a throttle located on the handlebar which activates the engine [5, 103], meaning pedalling is not necessary for propulsion and is therefore prohibited in the

European region [49]. The pedal-assisted bicycle (hereby referred to as E-bike) have a sensor, located on the pedals of the bicycle that activates the engine, thus is human powered and is legal in Europe according to the European legislation [49]. To elaborate, all E-bikes imported to Europe must comply with guidelines listed in the European Committee for Standardization EN15194 [49]. These guidelines clearly stated that; the engine is only to provide propulsion when the cyclist pedalling, with the exception of a start-up assistance of 6 km/h. Also, E-bikes is required to have a function that disconnects the engine when the cyclist stops pedalling, are braking or when velocity reaches 25 km/h [49]. Regulations are somewhat different between nations [52, 82, 88]. In USA and Canada the speed limit for E-biking with an active engine is 32 km/h, while only 19 km/h in China [103]. Furthermore, legislation in China, USA and Norway, classifies the E-bike as non-motorized vehicles allowing riders to travel in bike lanes without a driver’s license [88, 103]. It is also important to note that E-bikes must follow regulations similar to a conventional bicycle. That is, reflex and lights are required when cycling at night, while wearing a helmet is optional and there is no age limitation [88].

A large selection of E-bikes are available, in which often have a bicycle- or a moped style design of appearance with a rechargeable battery attached to the frame or the carrier in the back [52].

The E-bike provides assistance to propulsion when the rider is pedalling [82] which have an assistance setting that can normally be set at three or more levels. The highest assistance setting entails that engine delivers more propulsion than at moderate level. Logically, at the no-assistance setting the engine will not contribute to any propulsion, thus the power is entirely driven by human movements in the lower extremities [52].

2.6 E-bikes effect on transportation habits and cardiopulmonary fitness

The past decade, sales of E-bikes have rapidly increased [52]. For instance, sales rates of E-bike in Europe have increased tenfold from 2007 to 2012. Globally, it have been estimated that over 37 million E-bikes were sold in 2014 [52].

A study of Dill and Rose indicated that the main motivation for purchasing an E-bike were the extended ability beyond a conventional bicycle, followed by an alternative to cars as the second largest motivator [41], which may illustrate its potential for replacing other motorized mode of transport. Langford et al. [95] provided 93 students and staff members by the

University of Tennesse, with an available E-bike or conventional bicycle, through a Bikesharings system. Findings showed that E-bike journeys were 13 % longer than conventional bicycle, which most often were replaced by walking trips [95], although this might have been affected by the campus setting as student may not have access to a car. In an observational study investigating trends of mode of transport in China, the most replaced mode of transport to E-bike were bus (55 %) and cars (24 %), although the study also suggest that E-bikes have replaced trips from conventional bicycles (7 %). Furthermore, in six years the researchers observed an increasing popularity for using taxi or private cars and that the E-bike appeared to function as an interfering element in the transition to car, bus or taxi mode [30]. Moreover, in a conference proceeding, Cairns et al. [28] reported a reduction in driving distance of 29% in 80 adults after they were provided with an E-bike for eight weeks. These subjects cycled on average 15-20 kilometres a day, where 59% of the sample also reported having increased their overall level of physical activity during the intervention. Furthermore, 75 % of the sample reported that they would cycle to work if an E-bike were available [28].

In a RCT, Fyhri and Fernley investigated bicycle use with travel diaries, among 220 Norwegian adults, whereas 66 of them were provided with an E-bike for 3 and 1.5 months. The findings suggested a 20 % increase in bicycle use as a result of an available E-bike. More specifically, the number of cyclist increased by 22 %, distance per week increased by 27 kilometres and even an increase in frequency of trips [58] compared to a control group.

It have been well documented that cycling with a conventional bicycle can improve cardiopulmonary fitness in both children [22] and adults [37, 38, 72, 115]. However, findings from several studies have illustrated that intensity of physical activity while E-biking may be lower than by cycling with a conventional bicycle [61, 145, 153]. Also, the intensity of physical activity seems to be influence by assistance setting [61, 101, 144] and topography [145]. To elaborate, Theurel and colleges [153] observed, during a 30-minute indoor cycling test, lower heart rate and oxygen uptake by 24 % and 27 %, respectively, when cycling on an E-bike compared to a conventional bicycle. Similarly, Sperlich et al. [145] found 29 % lower heart rate and 33 % lower oxygen uptake, when individuals cycled at the highest assistance setting than no assistance setting of an E-bike. Compared to walking, Gojanovic and co-workers [61] observed a significant higher heart rate and oxygen uptake when E-biking at moderate assistance; although at the highest assistance setting, no difference between E-biking and walking where observed. Nevertheless, all studies indicate at least moderate intensity level (MET > 3) when E-biking [61, 101, 144, 145, 153] and two studies even found a vigorous intensity (MET > 6) in untrained [101] and inactive adults [61].

To the author’s knowledge, only one quasi experimental intervention study have examined the effect of E-biking on cardiopulmonary fitness. Geus and co-workers [60] conducted a study among 20 subjects who did not use physical active modes of transport prior intervention period. Cardiopulmonary fitness was measured as VO_2 max at baseline, after four weeks without an intervention and after six weeks of encouraged E-biking, with a maximal cycle ergometer test to exhaustion. The subjects’ travel diaries showed a mean daily distance of 15.5 kilometres in the intervention period of six weeks. However, distance cycled in the control period were not measured by travel diaries, leaving some uncertainty that the cycling have in fact, increased by the intervention. Most importantly, no significant difference in VO_2 max were found after four weeks without an intervention, neither after six weeks of cycling [60].

3.0 Subjects and methods

3.1 Study design

The present study used a longitudinal quasi-experimental design with an intervention. All participants' were provided with an E-bike, that they could dispose freely during the intervention period, for eight (n = 23) and three (n = 2) months. The participants recorded bicycle use using a bicycle computer enabled GPS (Garmin Edge 500, Southampton, UK) and performed a test of cardiopulmonary fitness measured as maximal oxygen uptake (VO_2 max) before and after the intervention. Pre- and post-tests took place in sports laboratories at the associated universities or colleges; at location 1 in Bergen, location 2 in Kristiansand and location 3 in Stavanger. Five types of E-bikes were distributed; Kalkhoff Derby Cycle Werke GmBh (Cloppenburg, Germany; n = 9), Diavelo Pure 3 (Denmark; n = 8), Giant Prime E+ 2 (Taichung, Taiwan; n = 6), Cannondale Mavaro HS City (Wilton, Connecticut, United States; n = 1) and Cannondale Mavaro HS Performance (Wilton, Connecticut, United States; n = 1).

The intervention started in September 2014 and lasted until June 2015, with some practical differences between the tests cities.

Location 1: A signed contract for disposal of an E-bike from each participant were collected (Appendix B). Additional equipment received were a bicycle lock and a bicycle helmet. The use of helmets were mandatory. All participants were provided winter tires, except the two participants who were recruited in March 2015. If the participant did not cycle for 2 weeks or less than 3 journeys per week over an extended period, the project manager could withdraw the E-bike with the associated equipment.

Location 2: A signed contract for participation from each company were collected (Appendix C). Additional equipment received were a front light, a bicycle lock, bicycle handbag and winter tires. The use of helmets were not mandatory. If the participants stopped cycle and did not intend to continue cycle the rest of the period, the project manager could withdraw the E-bike with the associated equipment.

Location 3: An informal contract for disposal of an E-bike were achieved by oral communication and by e-mail. Additional equipment received were a front light, a bicycle lock, bicycle handbag and winter tires. The use of helmets were not mandatory. The participants disposed the E-bike until the predetermined date of return at the end of the intervention.

All participants received oral and written information about the aim and methods of the project and signed a consent form (Appendix D). Participation were voluntary and participants were informed that they could withdraw at any moment of time without having to give a reason. The methods and results were anonymous and data material were treated confidentially. The study, methods and protocols were approved by Regional Committees for Medical and Health Research Ethics West (2014/603) (Appendix E).

3.2 Sample

Norwegian adults, 28 % men and 72 % women, aged 45 ± 12 years, were recruited through convenience sampling. After advertising about the study in location 1 and location 3 interested companies contacted the research team for further information and inclusion. In location 2, two companies with an environmental friendly profile were invited to participate by the research team, which they accepted. The representative leaders in each company managed recruitment of participants after being informed about the inclusion criteria in location 2 and 3, while the research team managed recruitment of participants in location 1 (Figure 1).

Twenty-three participants were included in September 2014 and additional two in March 2015 due to additional funding.

Inclusion criteria for participation were (1) 18 – 70 years of age, (2) vocational active, (3) residence ≥3 km from the workplace and (4) commute by motorized transport (car or bus) prior intervention period. Engagement in regular moderate intensity of physical activity ≥ 150 minutes- or ≥ 75 minutes / week of vigorous intensity, were considered exclusion criteria. This was specified further as exercise in 30 minutes twice per week (appendix D).

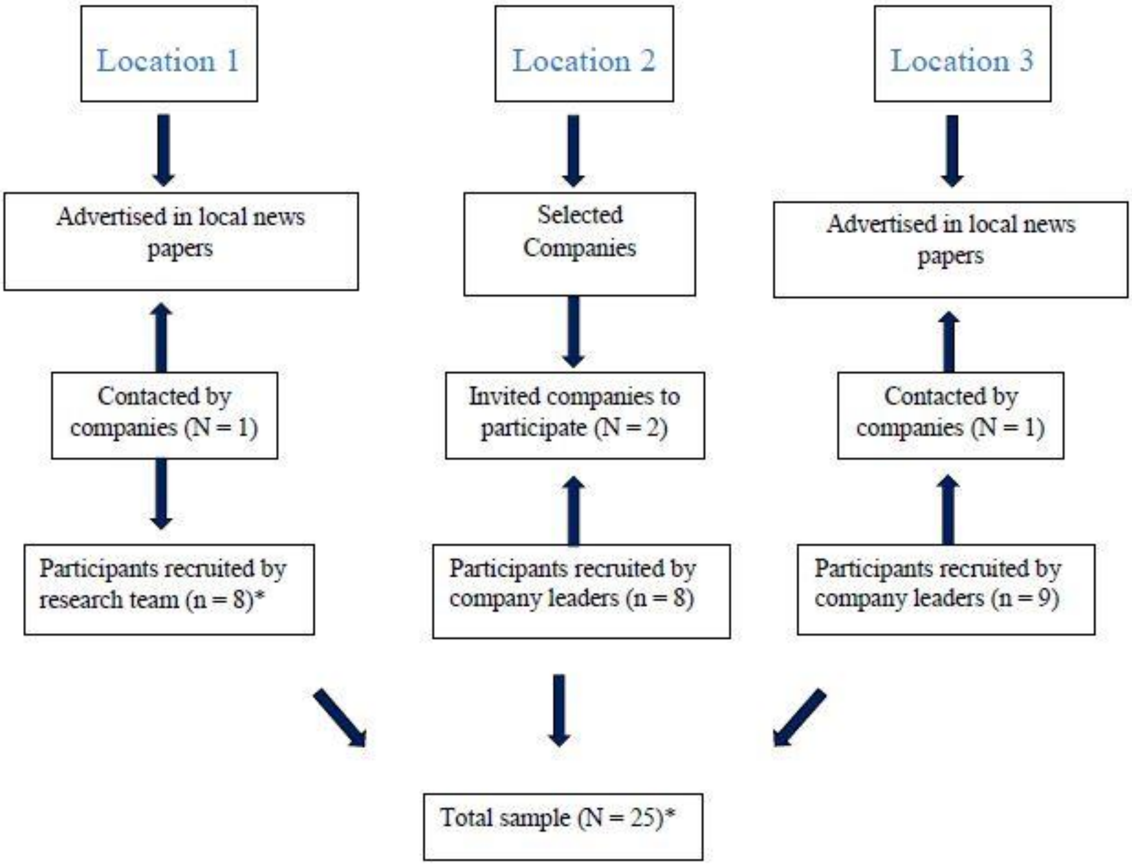

Figure 1: Recruitment process stratified by location.

* two participant were included in March.

3.3 Measurements

3.2.1 Questionnaire

Baseline questionnaire consisted of 13 questions about demographic characteristics (Appendix F). Data on relationship status, gender, age, education, working days a week, employment status (divided into part-time/full-time), travel distance to the workplace and bicycle ownership, both E-bike and conventional bicycle, and prior transportation habits in the summer- and winter year. The participants answered questions about their primary mode of transport; to the workplace, to kindergarten / elementary school, the supermarket, when shopping for other things, to leisure activities and transporting children to their leisure activities. The following categories; walking, bicycle/E-bike, car/motorcycle/moped, public transport and not relevant.

Education was assessed of years school and categorized into five categories; primary education (7 - 10 years), secondary education (upper high school ≤ 2 years), secondary education with an authorization (≥3 years and achieved certificate), college or university education (<4 years) and higher college or university (> 4 years).

3.2.3 Bicycle use

Cycling frequency, duration and distance in kilometres were measured using a GPS that should be attached on the handlebar of the bicycle. A member of the research team had access to the uploaded data and could contact participants if lack of upload over an extended time in order to offer guidance if needed. Participants were not encouraged to choose neither active nor motorized mode of transportation.

The bicycle computer given to the participants were a Garmin Edge 500 with GPS-system that records travel time, distance, speed, location and elevation gain with date- and time stamps. The device weighs 60 grams, has a 4.5 centimetre diagonal LCD screen and is powered by a rechargeable battery that can last for 18 hours. The participant could view ambient temperature, speed, distance and height above sea level in the LCD display, in which the participants could customize as desired.

The participants had to install Garmin Express software on a computer in order to transmit travel history to an online program, Garmin Connect. The first time participants should upload data from bicycle journeys they had to register themselves on the website www.connect.garmin.com. Charging occurs as long as the device is connected to a computer with a USB cable and data would be uploaded automatically. The participants were encouraged to upload cycling activity at least once a week.

Participants had full access to the uploaded travel history; that is, travelled time, speed, distances and routes viewed in maps, by logging into their users' accounts on Garmin Connect's website. Participants could also chose to be a part of an online community with other Garmin users, although this were not required to participate in the present study (Appendix G).

Data processing

The primary outcome from the GPS measurements were distance per week. Other variables included distance cycled on week days and weekend days and seasonal distance. Kilometres per weekday were calculated by summarising the trips distances from Monday to Friday and divided by five days. On weekend days, trips distances were summarised from Saturday to Sunday and divided by two days. Seasonal variables on cycled distance where calculated with means of calendar weeks that starts within the respective months. Autumn were defined as October and November, winter as December, January and February and spring as March, April and May.

Reasons for excluding data from GPS measurements were; signal dropout during the journey, recordings with minimal- or no movements or recordings of non-cycling activities. Crude cleaning procedures were performed by two people; LM and SL (author of thesis and research member). Every journey with unusual characteristics, such as extremely low or high velocity, -elevation, or -trip duration not corresponding to a common cycled journey, where checked and assessed for validity. Measurements where the bicycle was stationary resulted in minutes up to several hours with no movements and a low average speed, which were corrected by removing stationary time from the journey. Also, if the device were not turned off when reaching the journey destination (for example at the supermarket, workplace, kindergarten), both the trip to and from the destination were automatically registered as a single bicycle trip. Several participants did not restart the device until the end of the day, which in turn caused the GPS to register all bicycle journeys as a single trip. For this reason, distance per trip were categorised into distance per day, by summarising all trips of the 24-hours within the respective date. Furthermore, if signal loss occurred the data most often became highly skewed, in which the entire trip where rejected from the data material. Also, walking, jogging and/or exercise were registered by some participants (most often manually) and were excluded from the data material.

Participants were instructed to label bicycle trip with intent, that is, commuting or non-commuting purposes, as well as labelling type of bicycle (E-bike or conventional bicycle). However, due to the low maintenance in this aspect of the protocol (appendix G), all data from GPS measurements are presented as cycling, as it was not possible to stratify the journeys by purpose or mode. Nevertheless, it is worth mentioning that the participants were contacted by email on the 9th of September 2015, and asked which bicycle mode they had initiated during the intervention period, in which all replied that E-bikes were used, although details on every trip does not exist.

3.2.2 Cardiopulmonary fitness

Three types of gas analysers were used to measure gas exchange values. In location 1 and 2, Oxycon Pro, (Jaeger GmbH, BeNeLux, Breda, Netherland) was used at baseline and post-test. In location 3, Vmax 29 (Sensor Medics, Yorba Linda, CA, USA) was used at baseline, however, due to technical problems, the analyser were subsequently replaced with Vintus CPX, (Care Fusion, Hochberg, Germany) at post-test. Measurements of heart rate (HR), respiratory exchange ratio (RER), minute ventilation (V_E) and peak oxygen uptake (VO_2 peak) were collected as 1-minute average.

The participants were verbally encouraged by the test leaders to achieve their maximal effort during the two tests. Criteria for acceptable VO_2 max were the subjective assessment from the test leader that maximum exertion had been achieved, through observations of parameters, verbal feedbacks and physical appearance of the participant being tested.

Preparation

A trained instructor calibrated the gas analyser in advance following the instruction from the manufactory. Before the test began, height and weight were recorded followed by dressing a pre-moistened heart rate sensor (Polar S610i, Polar Electro, Oy, Kempele, Finland) attached to the thorax. The participants self-reported height at location 2 and 3 and were measured by the test leader at location 1. Weight was measured to the nearest 0.1 kg with a body composition analyser in location 1 (Inbody 720, Biospace, Korea) and a beam body weight scale; Seca 713 (Hamburg, Germany) and Seca 770 (Hamburg, Germany) at location 2 and -3, respectively. A mask (V2 Mask, Cosmed, Rome, Italy and Hans Rudolph Inc., Shawnee, Oklahoma, USA) was clothed with guidance from the test leader. All masks were carefully checked for leakage. The participants personal details, id numbers, height- and weight values were registered and the test protocol was described by the test leaders.

Test-protocol

A modified Balke-protocol according to Edvardsen et al. [45] were followed, while walking/running on a motorised treadmill; Woodway, Ergo ELG (Weil am Rhein, Tyskland) and Katana Sport, AkuMed (Oslo, Norway). The test began with five minutes walking at a speed of 4.8 km/h with 4% incline on the treadmill. Inclination increased with two percent per minute, until maximum incline at 20 %. Thereafter, speed increased by 0.5 km/h per minute (Figure 2).

To measure level of perceived exertion a validated [100, 135] subjective scale developed by Gunnar Borg was used. Immediately after completed the tests, the participants were asked to rate how strenuous the test was while a figure of the scale was held in front of them. The Borg's Rating of Perceived Effort (RPE) scale 6 - 20 starts on the number six that represents "no exertion" up to the number twenty that represents "maximum exertion".

Data processing

BMI were calculated according to the international standard of BMI classification [169]. The sample were categorised into two groups according to fitness status at baseline; participants below (defined as low fit) and above (defined as high fit) the representative VO_2 max values of the Norwegian population. Expected values where calculated by a prediction equation for men (VO_2 max = 60.9 − 0.43 × age) and for women (VO_2 max = 48.2 − 0.32 × age) retrieved from Edvardsen et al. [46].

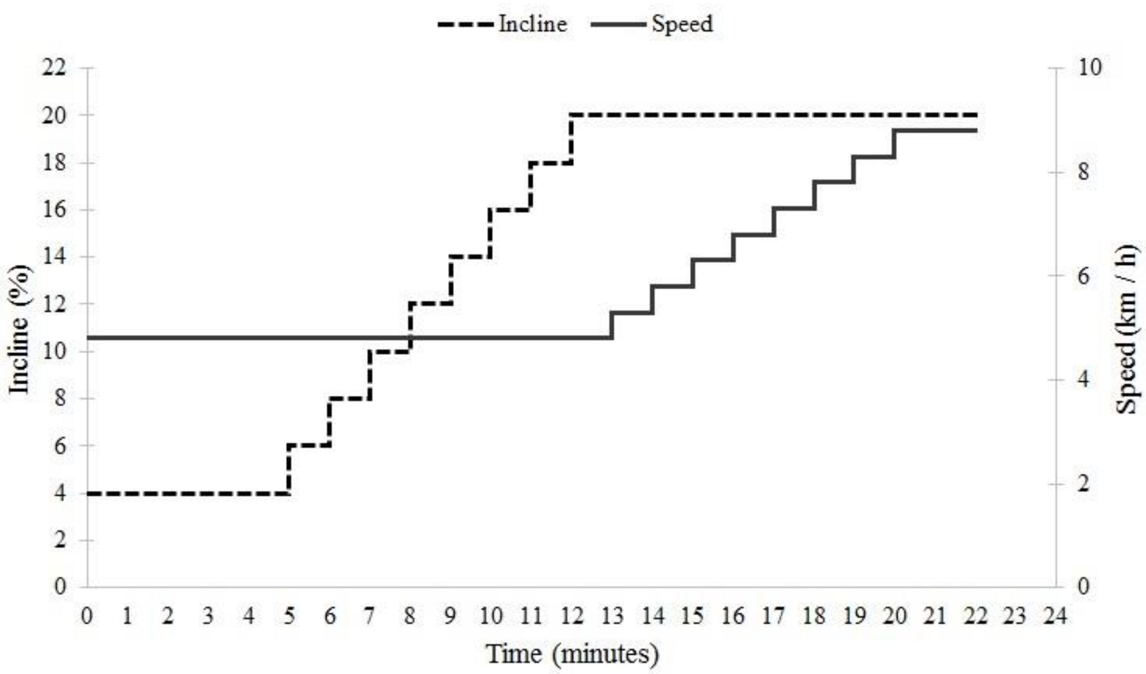

Figure 2: The modified Balke test protocol used in the present study.

3.4 Statistical analysis

Statistical analyses were carried out using Statistical Package for Social Sciences, version 22 (SPSS, Armonk, NY, USA). Significance level were set at $P < 0.05$.

Determining normal distribution of variables were based on an overall assessment of histogram, skewness, the Shapiro-Wilk test of normality, Q-Q plots and by comparison of median and mean. Variables that were assessed as not normally distributed were cycled distance per week, cycled distance by season, time spent in cycling, elevation gain, and BMI. Therefore, cycled distance were transformed using Log10 in order to satisfy normality assumption required by Pearsons'r.

Descriptive data are presented as mean and standard deviation (SD), numbers and percent or median and range for skewed variables. Results are presented as mean and 95 % confidence intervals. Paired-samples t-test was used to analyze differences between pretest and post-test and independed-samples t-test for differences between the high- and low fit group. The association between distance per week and changes in VO_2 max was analyzed using Pearsons'r.

In the present study, four participants did not complete VO_2 max post-test and four participants did not have valid GPS data (16 % and 16 % missing data, respectively). Furthermore, five participants did not record valid date specific GPS measurements. In the present analysis, two participants were excluded in the seasonal comparison of cycled distance, due to a shorter intervention period of only three months.

4.0 Method discussion

4.1 Study design

The present study used a longitudinal design with continuously measurement of cycled trips and repeated measures of cardiopulmonary fitness to assess the effect of the intervention, which consisted in giving access to an E-bike.

The present design gives the advantage of investigating trends, changes over time and as well as correlations between variables. However, randomised controlled trails with doubled blinding experiments have been perceived as the gold standard of intervention studies [70, 139] because of the ability to investigate causal relationships. Hegedus and Moody noted that in non-randomised interventions, all confounder variables can not be accounted for, and consequently may cause a misinterpreted effect of the intervention [70]. A study conducted by Shadish and colleges investigated this effect by randomly assigned 445 student to a randomised experiment or a nonrandomised experiment and found a greater effect (9 – 25 %) in the nonrandomised group [139] that might be explained by selection bias, such as inclusion of highly motivated participants [81]. Even though Shadish and colleges [139] studied mathematics- and vocabulary progression, the experiment does illustrate how bias might occur without randomization. Furthermore, doubled blinding experiments would have adjusted for the placebo effect, however, blinding may not be feasible in behavioural interventions [81].

Only two intervention studies were found that investigated the effect of an available E-bike [58, 95]. With respect to conventional bicycles, interventions have most often encouraged or guided participants to cycle [38, 72, 115]. The present intervention provided the ability to assess the independent effect of an available E-bike, without the interference of guidance or encouragement to use. However, the participants were also provided with a GPS in order to collect data on cycled trips, in which the participants had full access to the recordings. This can have induced a behaviour of self-monitoring, which in turn might have affected the results. Self-monitoring have been used as a behaviour change strategy in intervention studies to promote cycling and walking [15] as it is thought to increase awareness and self-efficacy thus lead to greater adherence to the behaviour in question. Therefore, the effect of intervention might be misinterpreted by self-monitoring of cycled activity. However, in a non-RCT study conducted by Piwek and colleges [121], a conventional bicycle with a pedometer attached under the seat were provided to 23 students, where only the researchers had access to the recordings from the pedometer. About half of the students were also given a bicycle computer with full access to travel history, in order to self-monitor cycled behaviour. No significant difference in distance and frequency were observed between the two groups, indicating a little influence of a given GPS on cycling behaviour. Moreover, in a metaanalysis conducted by Mateo et al., investigating self-monitoring of physical activity in mobile apps, no significant increase in physical activity were observed. Also, the self-monitoring behaviour seemed to languish over time [54], in which underlines the importance of an extended intervention period.

4.2 Sample

In the present study, 25 participants (72 % women) were recruited through convenience sampling in three different Norwegian municipalities.

Women were overrepresented in the present study, which might have affected cycled distance and patterns of cycled trips. Fyhri and Fearnley [58] observed, after providing an E-bike for three months, a greater percentage of cyclist and greater frequencies of trips in female participants compared to male participants. However, female participants cycled 42 km/week compared to 82 km/week reported by male participants. Another characteristic that might have influenced cycled distance in the present study is diversity in geographical areas, since topography, hills and infrastructure have previously shown to influencing factors for cycling with an E-bike [165] and conventional bicycles [126, 152, 154].

Implementing the intervention in different geographical areas, might increase the generalizability, although the small sample size does not. Results from pilot studies can be used to estimate the sample sizes in a large-scale full powered study [33], by using mean and standard deviation to calculate sample size. Therefore, estimation of sample size prior pilot studies may be more problematic since a mean and standard error of the intervention effect have not yet been estimated. As a thumb rule, Julious suggested at least 12 participants in pilot study designs [83] due to a feasibility and precision calculations. According to Hertzog [73], sample size should vary with the purpose of the pilot study, which was in the present study, to investigate preliminary results of the intervention’s efficacy in a small-scale clinical study. Furthermore, Hertzog [73] recommended a sample size of 20 – 25 individuals when investigating the effect of an intervention in a single group. However, in the present study, sub-analysis based on initial fitness status was conducted where only five participants had a fitness level above the predicted value, which resulted in a lower precision of mean and variance according to Julious's estimates [83]. An insufficient sample size may cause an underestimation of the intervention effect [70, 73], thus increase the risk of a type II error; that is, failing to detect an significant difference in the sample [166]. Therefore, imprecision of estimates in the present analysis must be considered when interpreting the findings.

Convenience sampling entails recruitment of the most available individuals and are therefore feasible, cost-effective and less time consuming; however, due to the high risk of recruiting individuals who are atypical for the main population, the participants are highly susceptible for confounding factors, therefore may not provide a representative sample [70, 122].

As mentioned in section 3.2, there were some differences in recruitment strategy between the test cities, which may have influenced the sample characteristics. During the recruitment process, decisions to include participants were made by several persons; both company leaders and research members. Interpreting the eligibility criteria and inclusion interviews rely on the subjective assessment of the person in charge, thus, having a single researcher responsible of the recruitment task could have increased consistency.

4.3 Measurements

4.3.1 Bicycle use

In the present study, a bicycle computer with GPS were used to measure cycled trips, in which cycled distance were the main outcome variable. The test protocol required participants to administer the device, managing uploading the data to a software program and remember to recharge the device regularly. Crude cleaning procedures were performed resulting in exclusion of trips with signal dropouts, no movements and non-cycling activities.

To the author's knowledge, it does not exist any published validation studies on distance with Garmin Edge 500 in particular. However, one validation study including Garmin Edge 500 were found investigating elevation accuracy and found no significant differences in devices within the same brand, although differences were seen between different brands of GPS devices [110]. Garmin is one of the leading brands in the market of GPS enabled bicycle computers, and other GPS-devices from Garmin have been validated on travel behaviour [43, 105].

The main advantage of using a GPS is the ability to navigate actual travel routes taken, in contrast to commonly used self-reported and estimation based on geographical information systems (GIS) [42]. To elaborate, GIS estimation entails calculating the shortest route from reported addresses from departure to destination [164]. However, the shortest routes is not necessarily the one that is travelled. Broach et al. found that route choice may be influenced by avoidance of intersections, the number of turns and high inclination, which in turn may be influenced by commuting- or non-commuting purposes [26]. Self-reported measurements, such as questionnaires and travel diaries, require participants to recall and estimate distance, which are prone estimation bias. For example, studies have indicated that distances can be perceived as longer when individuals are tired [124], when estimating distance with varied topography [146], or travelled routes with multiple intersections and turns [63] which may cause an overestimation of actual travelled distances. In a metaanalysis, Kelly and colleges [87] found that self-reported trip duration was overestimated by 28.6% (ranging from +2.2 to +75.4%) compared to GPS measurements. Likewise, Stigell and Schantz [149] found a higher correlation between repeated tests with a GPS ($r = 0.98$) than self-estimation of distances ($r = 0.75$), indicating that GPS measurements may produce more reliable results. In summary, the GPS seems to be a more accurate method to measure distances, duration and frequency, in active travel. However, this measurement is not without limitations.

In the present study, several trips were excluded due to signal dropouts or measurements without movements. In addition, some of the participants noted technical difficulties when uploading GPS to Garmin Connect and some reported difficulties to maintain continuous GPS signal while cycling. Thus, these issues could have caused an underestimation of cycled distance (se section 3.2.1). Others have documented similar technical issues causing loss of travel data with GPS measurements. According to a systematic review by Krenn et al. [93], the main reasons of data loss from GPS measurements were failed to achieve reception, signal noise, battery run out, participants compliance to measurement protocol and signal loss during the initialization period, in that order.

An initialization period occurs when the GPS is started, which entails receiving reception from at least four satellites to estimate position and can last from 15 – 45 seconds [43]. The initialization period of Garmin Edge 500 range between 30 – 60 seconds [59], and it is important for participants not to start cycling, until the GPS have achieved position acquisition. Stopher and co-workers reported that, by moving the GPS device before satellite reception have been accomplished, time to position acquisition can take up to 15 minutes

[150] and relevant cycling data may be lost. Therefore, a possible explanation of why trips without any movements were measured may be that participants in the present study did not acquire satellite position before they started cycling, and as have been observed in other studies, signal loss can cause exclusion of an entire trip [42]. The initialization period is longer for a cold start (when the GPS is not used regularly and/or have changed location) than for warm starts (when the GPS is used frequently) [42, 105, 150], indicating that signal errors may be more likely to have occurred with participants who cycled the least.

In the present study, only crude cleaning procedures where performed, mainly consisted of exclusions of abnormal trips. However, other cleaning procedures have recommended, involving correction of errors caused by signal dropout or signal noise during a trip [43, 150]. These procedures could have increased internal validity by preventing some of the exclusion of trips. Duncan et al. [43] found that cleaning protocols can increase the quality of the measurements, however, using raw data from GPS were sufficiently accurate to measure cycling distance.

Low participants adherence to GPS measurement protocol have been serving as a major cause of data loss. Krenn et al. [93] found that GPS loss were highly correlated ($r = 0.80$) with measurement period and were estimated as the third greatest causes of data loss from GPS measurement. Another major cause of data loss is battery capacity [93, 120], which according to the Garmin Edge 500 manual is up to 18 hours [59], thus could also data loss, as participants were required to remember charging the GPS during the eight months period.

Distance per week were set as the outcome variable and measure of bicycle use, although other studies have used time spent in cycling [87], which naturally is affected by velocity. Velocity varies between participants and between journeys. Broach et al. showed that trips of commuting purposes cycled at a higher speed (19 km/h) than non-commuting trips (16 km/h) [26] indicating that velocity may be influence by purpose and time pressure. Other factors may be characteristics of the cycling route such as the number of stops at intersections and traffic lights or number of turns. Therefore, distance may be a more comparable measure between and within subject and more appropriate determinant of cardiopulmonary fitness than the time spent in cycling.

Finally, it is worth mentioning that the present study have had some media attention [57, 62, 96, 118, 138, 147, 148] which could may have influenced motivation in cycling behaviour.

4.3.2 Cardiopulmonary fitness

Cardiopulmonary fitness were measured as maximal oxygen uptake, with direct measurements during a modified Balke protocol, in the present study. The protocol mostly require individuals to walk on a treadmill, although it might include running at a low pace for some individuals continuing the test after 16 minutes (section 3.2.2, figure 2). An advantage of this particular protocol is that walking behaviour is likely to be a familiar activity to most individuals and does not require a specific set of skills to perform, unlike running and cycling [116]. In fact, Lucia et al. [102] found that cycling economy may influence the VO_2 max during a maximal graded exercise test, indicating that a learning effect would have occurred from baseline to post test due to increased cycling experience.

Furthermore, repetition of tests can induce a habituation effect due to familiarization of the tes protocol that may cause an increase in VO_2 max [56]. By comparing to a control group or by adding a third VO_2 max tests, this effect would be accounted for such as in the study of Geus et al. [60]. However, from test 1 to test 2, in the control period, no difference in VO_2 max, measured by a cycle ergometer where observed, neither at test 3.

A subgroup analysis were conducted by extracting two groups based on initial fitness status. The cut-off point was set based on references values from the Norwegian population [46] to stratify the sample into a high fit and low fit category. These reference values is highly applicable to our sample, as the same test protocol were used [45]. However, it is worth mentioning that other reference values on larger-scale studies exists [86, 100]. Loe et al. tested 3816 adults in the county of Trøndelag, with a running protocol on a treadmill [100], and found higher mean VO_2 max values in all age groups, compared to the 759 adults tested by Edvardsen et al. [46]. In contrast, Kaminsky and colleges tested 7783 individuals in eight laboratories in the U.S. and found lower VO_2 max reference values in all age groups [86] compared to Edvardsen et al. [46]. The differences might be due to variance in protocols or variance within geographical areas.

The intervention period in the present study lasted for eight months, that started in autumn and ended in spring, which provided the ability to assess cardiopulmonary fitness after an extended period. Nevertheless, previous research shows that populations in industrial countries increase level of leisure time physical activity during the summer season [142], thus decrease the comparability of the repeated VO_2 max tests. However, to some extent, correlation analysis adjusts for other physical activity.

4.4 Ethical considerations

The participants were not instructed to perform any transport behaviour; however, by providing access to an E-bike, the cycling behaviour was facilitated. Therefore, it is important to address the potential health risk in performing such behaviour.

Evidence have indicated that risk of travel accidents are greater when travelling by conventional bicycles, compared to traveling with motorised transportation [39, 127]. With respect to E-bikes, Schepers and colleges [134] found that cycling on an E-bike may increase the risk of cycling accidence compared to conventional bicycles, although the severity might similar for both bicycle types. Initiatives related to possible injuries in the present study were to encourage participants to wear bicycle helmets when cycling as well as require that all included participants had insurance that covered cycling accidents.

Cyclist may be more susceptible to air pollutants than drivers or passengers in a car or a bus [39, 79, 127], which in turn have shown increase the risk of mortality [39], asthma, reduction in lung function and high blood pressure [14]. Exposure may be somewhat higher for car- or bus passengers, as they are located closer to the source [39]; however, studies have measured between two to four times higher minute ventilation in cyclist compared to car passengers [39, 79], causing a larger amount of inhaled air pollution. Although, minute ventilation when cycling on an E-bike may be lower than conventional bicycles [145].

The implied assumption in the present study, is that E-biking could increase physical activity. Compared to conventional bicycles, Hartog et al. estimated that, by replacing motorised transportation with cycling, the risk reduction for all-cause mortality, due to increased physical activity were remarkably higher (0.500 - 0.900) than the risk of mortality due to increased exposure to air pollution (1.001-1.053) and accidents (0.993-1.020) [39]. This illustrates that the health benefits may be greater than the health risk when substituting driving with cycling, which have been supported by others [127]. However, these estimates were based on conventional bicycles, leaving some uncertainty whether similar associations would apply to E-biking as well.

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APPENDIX

Appendix A – The article manuscript

How access to an E-bike affects bicycle use and cardiopulmonary fitness in inactive Norwegian adults: A pilot study.

Lena Hansen Malnes[1]

[1]Department of Public Health, Sport and Nutrition

Faculty of Health and Sport Sciences

University of Agder, Kristiansand, Norway

*The present article is written as a part of a master thesis in Public Health Science and is written by the corresponding author. Relevant co-authors are Stian Lobben, Elling Bere, Leif Inge Tjelta, Morten Kristoffersen, Thomas Mildestvedt, Sveinung Berntsen.

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Corresponding author:

Lena Malnes

University of Agder

Faculty of Health and Sport Sciences

PO. Box 422

4604 Kristiansand, Norway

Tel: +47 472 91 022

E-mail: lena.h.malnes@gmail.com

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Abstract

Background: Electric assisted bicycles (E-bikes) have become increasingly popular worldwide during the last decade. Bicycle use with an E-bike (E-biking) may be categorized as a physical activity of moderate intensity. The aims of the present study were to assess the effect of an eight-month intervention with access to an E-bike on (1) the amount of E-biking, (2) changes in cardiopulmonary fitness and (3) to assess whether cycled distance was associated with changes in maximal oxygen uptake (VO_2 max), among inactive adults. **Methods**: Twenty-five inactive Norwegian adults (33 – 57 years of age, 72 % women) who did not cycle or walk to work, were recruited in September 2014. Participants were given an E-bike for eight (N = 23) or three (N = 2) months. Demographic characteristics were reported with a questionnaire and bicycle use was measured with GPS bicycle computer. The participants′ VO_2 max was directly measured, before and after the intervention, using a modified Balke protocol while walking/running on a treadmill until exhaustion. **Results**: During the intervention, participants spent on average 107 ± 62 minutes cycling per week covering 37.6 ± 24 kilometres per week. Participants cycled significantly ($P < 0.001$) more on weekdays (7.1 km / day) compared to weekend days (0.9 km / day). A significant improvement in VO_2 max (7.7 %, $P < 0.001$) from baseline (34.1 ml/kg/min) to post test (36.4 ml/kg/min) was observed, improvement in VO_2 max was associated with cycling distance (r = 0.49, P = 0.042). When stratified by cardiopulmonary fitness status at baseline (defined as below or above predicted VO_2 max value adjusted for age and gender), the group with lower fitness had a considerable increase in VO_2 max (9.6 %, P <0.001) associated with cycling distance (r = 0.64, $P = 0.014$), while no changes were observed in the group with higher fitness (1.5 %, P = 0.626). **Conclusion**: Access to an E-bike for eight months resulted in average 37.6 km/week, and it was associated with 7.7 % improvements in cardiopulmonary fitness. E-bikes may contribute to mobilize inactive individuals to initiate transport-related physical activity.

Keywords

Active commuting, electric assisted bicycle, cycling distance, maximal oxygen uptake.

Background

Physical activity may reduce all-cause mortality [1, 2] and risk of several non-communicable diseases [2, 3]. However, prevalence of adherence in recommended 150 minutes of moderate physical activity per week [4] are low in several industrial countries [5-8].

One of many areas for promoting physical activity is active travel. Evidence have indicated that using physically active modes of transportation can increase level of physical activity, compared to using motorized modes such as a private car or public transportation [9, 10]. However, a representative Norwegian survey showed that a minority of daily trips are by foot (21 %) and even fewer on bicycles (5 %) [11].

In the past decades promotion of active travel has emphasized walking [12] and bicycling [13]; however, few intervention studies have focused on E-bikes. Meanwhile, sales of E-bikes have increased almost tenfold between 2007 and 2012 in Europe [14]. In Europe, an E-bike is defined as a bicycle as human movement in the lower extremities cause pedalling propulsion similar to a conventional bike, making them capable of riding in bicycle lanes as long as speed powered by the motor does not exceed the restrictive limits of 25 km / h [14]. An E-bike has an electric engine that provides additional assistance and complements the rider when is pedalling, which usually can be set at three settings [14]. According to Simons et al. [15], this assistance may influence intensity of physical activity performed by the rider. In essence, the findings indicated at least moderate intensity of physical activity when cycling on an E-bike, defined as metabolic equivalents ≥ 3, in twelve subjects [15], which have been supported by others [16-18]. Indeed, two studies indicated vigorous intensity, defined as MET ≥ 6, in inactive [17] and untrained [16] subjects at every assistance setting.

Interestingly, findings from other studies have indicated an increase in the amount of cycling with an E-bike [19, 20]. In a randomised controlled study, 66 Norwegian adults, who were recruited from the Norwegian Automobile Federation, were provided with an E-bike. The findings showed a 20 % increase in bicycle use, in contrast to a control group where no changes were observed [20]. More specifically, in the intervention group, percentage of bicyclist increased by 22 %, frequencies of trips from 0.93 to 1.4 per day and distance significantly increased by 28 kilometres per week [20]. In qualitative interviews of 27 E-bike users, the respondents reported that they experienced less travel range, exposure to poor weather conditions and more travel time as disadvantages of E-bike use compared to driving. [21] However, experienced benefits were less pollution and less economic cost among respondents of E-bike users in the U.S [21]. Compared with conventional bicycles, respondents in qualitative studies experienced E-bike as expensive, yet achieved greater speed and maintenance of high velocity with less effort [21, 22]. Which is supported by other studies showing significantly less perceived exertion [17, 18, 23] and greater enjoyment [18] when riding E-bikes compared to an conventional bicycle.

To the authors' knowledge, only one intervention study including commuting with E-bikes and with measures of cardiopulmonary fitness is published. Geus et al. [24] conducted a quasi-experimental intervention, in twenty inactive adults, who cycled a mean distance of 15.5 kilometres a day measured by travel diaries. No significant changes in cardiopulmonary fitness measured as maximal oxygen uptake (VO_2 max) after only six weeks of disposing an E-bike, were found.

Physical effort is required when riding an E-bike, which can make it a source of physical activity [15]. Although whether adherence in cycling over time with an E-bike (E-biking) is enough to improve cardiopulmonary fitness have not been fully established. In addition, no intervention studies have measured cycled distance objectively with a GPS, when providing access to an E-bike. The aims of the present study were to assess the effect of an eight-month intervention with access to an E-bike on (1) the amount of E-biking, (2) changes in cardiopulmonary fitness and (3) to assess whether cycled distance was associated with changes in maximal oxygen uptake (VO_2 max), among inactive adults.

Methods and materials

Study design and sample

In the present study, inactive Norwegian adults were given an E-bike and a bicycle computer with GPS. Cardiopulmonary fitness was recorded pre and post intervention and demographic characteristics as well as prior transportation habits were collected in a questionnaire before the invention period. Bicycle use was obtained during the intervention using a bicycle computer with GPS.

After an informational meeting, each included participants were handed an E-bike that they could dispose freely during the intervention period. Five types of E-bikes were distributed; Kalkhoff Derby Cycle Werke GmBh (Cloppenburg, Germany; n = 9), Diavelo Pure 3 (Denmark; n = 8), Giant Prime E+ 2 (Taichung, Taiwan; n = 6), Cannondale Mavaro HS City (Wilton, Connecticut, United States; n = 1) and Cannondale Mavaro HS Performance (Wilton, Connecticut, United States; n = 1). Participants also received an extra set of winter tires and a service package, which included repairs in a workshop if needed.

Twenty five participants (72 % women), 33 – 57 years of age, were recruited through their respective workplace in three Norwegian municipalities. Twenty three were recruited in September 2014 and two in March 2015 due to additional funding, resulting in an intervention period of eight and three months, respectively. Inclusion criteria were (1) 18 – 70 years of age, (2) residence > 3 km from the workplace and (3) commute by motorized transport. Engagement in regular moderate intensity of physical activity ≥ 150 minutes- or ≥ 75 minutes / week of vigorous intensity, were considered exclusion criteria.

Four participants did not complete post testing and four participants did not have valid GPS data (16 % and 16 % missing data, respectively). Furthermore, five participants did not record valid date specific GPS measurements.

All participants signed a consent form and had insurance that covered cycling accidents. The present study was approve by the Regional Committees for Medical and Health Research Ethics West (2014/603).

Measurements

Bicycle use

Variables on prior transportation modes for commuting and non-commuting purposes were measured by a questionnaire at baseline.

The participants were instructed to attach a portable GPS, Garmin Edge 500 (Southampton, UK), to the bicycle when used. A written user manual was handed out describing how to upload data. If technical issues of measuring trips with GPS occurred, an alternative were entering data into the software Garmin Connect (https://connect.garmin.com/) manually. Also, guidance by email and telephone were offered.

Variables included from GPS measurements were time (minutes), distance, speed and elevation gain (i.e. vertical metres cycled uphill), presented per day, week and season. Seasonal variables on cycling distance where calculated with means of calendar week that starts within the respective months. Autumn was defined as October and November, winter as December, January and February and spring as March, April and May. Reasons for excluding GPS data from the analyses were; loss of GPS signal during the trip or data with no or minimal movements (which occurred if participants failed to turn of the bicycle computer after parking the bicycle or where no GPS reception was achieved). Only 2.3 % of trips were self-reported (manually entered in Garmin Connect). Therefore, it was not appropriate to conduct separate analyses and all data on distance and minutes spent cycled were considered as objective measurements.

Cardiorespiratory fitness

Treadmill walking/running to exhaustion using a modified Balke-protocol according to Edvardsen et al. [25] were followed. The test started with a five minutes warmup at a pace of 4.8 km/h with 4% incline on the treadmill. Inclination increased with two percent per minute, until maximum incline at 20 %. Thereafter, speed increased by 0.5 km/h per minute. VO_2 max, minute ventilation (V_E), and respiratory exchange ratio (RER) were measured by indirect calorimetry. Heart rate (HR) was registered every minute with a heart rate monitor Polar S610i, (Polar Electro, Oy, Kempele, Finland). Time to exhaustion was measured as the number of minutes from test start to maximal exhaustion. Three types of gas analyzers were used; Oxycon Pro, (Jaeger GmbH, BeNeLux, Breda, Netherland) at two of the test centres, whereas Vmax 29 (Sensor Medics, Yorba Linda, CA, USA) and Vintus CPX, (Care Fusion, Hochberg, Germany) where used at pre- and post-test, respectively, at one test center. All gas analyzers were calibrated in advance and masks were checked for leakage when clothed.

The participants were verbally encouraged by the test leaders to achieve their maximal effort during the test. Criteria for acceptable VO_2 max were the subjective assessment from the test leader that maximum exertion had been achieved.

The sample were categorised into two groups according to fitness status at baseline; participants below (defined as low fit) and above (defined as high fit) the representative VO_2 max values of the Norwegian population. Expected values where calculated by a prediction equation for men (VO_2 max = 60.9 − 0.43 × age) and for women (VO_2 max = 48.2 − 0.32 × age) retrieved from Edvardsen et al. [26].

Body weight were measured to the nearest 0.1 kg using a body composition analyzer at one test center with Inbody 720 (Biospace, Korea) and body weight scales at the other two; Seca 713 (Hamburg, Germany) and Seca 770 (Hamburg, Germany). Participants self-reported height.

Statistical analysis

Statistical analyses were carried out using Statistical Package for Social Sciences, version 22 (SPSS, Armonk, NY, USA). Descriptive data are presented as mean and standard deviation (SD), numbers and percent or median and range for highly skewed data. Results are presented as mean and 95 % confidence intervals (CI). Paired-samples t-test was used to analyze differences between pretest and post-test and independed-samples t-test for differences between groups. The association between variables was analyzed using Pearons'r. Distance per week where transformed using Log10 in order to satisfy normality assumption required by Pearsons'r.

Results

Of twenty-five participants at baseline, eighteen had a university education, twenty-three worked full time, twenty-two were nonsmokers and twenty commuted by car or moped, while the others commuted by public transportation (table 1). Seventeen of twenty-five participants had a VO_2 max below predicted value. Nine participants were normal weight and the other were either overweight or obese (twelve and four, respectively), at baseline (table 1). Furthermore, twenty-two participants owned a conventional bike and five owned an E-bike.

Prior transportation modes

Of the 25 participants, only one reported walking to the supermarket and two walking their kids to kindergarten/school as primary mode of transport in the winter season. In the summer season, two reported walking or cycling to the supermarket, two walking or cycling with their kids to kindergarten/school and one reported cycling to leisure activities as primary mode of transport. The remaining participants reported using motorized transport (car, moped, motorcycle or bus) in non-work related travel and all participants reported using motorized transportation to and from work.

Bicycle use

During the intervention period, total mean (SD) distance cycled was 37.6 (24.0) km/week in eight months (table 2). The low fit group cycled on average 36.1 (25.6) km/week and the high fit group cycled 43.8 (16.4) km/week, which were not significantly (P = 0.472) different (not shown). Participants cycled significantly ($P < 0.001$) more on weekdays compared to weekend days (table 2). Figure 1 show distance by season, which indicate a reduction over time, where cycled distance were significantly ($P = 0.035$) higher in autumn (47.4 km/week) compared to distance in the spring (32.1 km/week). Cycled distance in the winter (36.4 km/week) were not significant different from autumn (P = 0.085) or spring (P = 0.175).

Figure 2 shows patterns in cycling distance during the intervention period, where a decline was observed around holidays when vacation days occur, on calendar week 52 (Christmas) and calendar week 14 (Easter). Lowest mean (SD) weekly distance of 8.42 km (17.6) were observed in calendar week 52 in December. Elevation correlated ($R = 0.93$, $P < 0.001$) with distance, indicating that the same cycling route have been used frequently. All twenty participants cycled at least one weekday

(Monday to Friday), while only thirteen participants cycled at least one weekend day (Saturday to Sunday) (table 2).

Fitness

A significant (*P <0.001*) improvement (7.7 percent [%], [95 % CI: 4.3, 11.1]) was observed from pre- to post-test in VO_2 max (table 3). After stratifying by fitness status at baseline a significant (*P <0.001)* increase in fitness (VO_2 max gain 9.6 %, [5.9, 13.3]) was found in the low fit group, but not in the high fit group (VO_2 max gain 1.5 %, [-5.6, 8.6], *P* = 0.626) as illustrated in Figure 3a. In addition, no significant difference (P = 0.069) in test time (time to exhaustion) where observed (gain in minutes 10.3 %, [1.6, 19.2]) were observed. When stratified by fitness status at baseline time to exhaustion increased significantly (gain in minutes 14.3 %, [4.1, 24.5], *P = 0.028*), among participants in the low fit group. Whereas no changes (P = 0.561) were seen in the group with higher fitness at baseline (gain in minutes -2.5 % [-22.3, 17.3]), as shown in Figure 3b.

Correlations between fitness and bicycle use

A significant correlation between weekly distance cycled and gain in VO_2 max were observed (*r* = 0.49, *P = 0.042*). In particular, the low fit group had a strong significant correlation (*r* = 0.64, *P = 0.014*) whereas those in the high fit group did not (r = 0.26, P = 0.743) (figure 4).

Discussion

In the present study, total cycled distance in eight (three) months were 37.6 km per week. We observed a reduction over time, where distance- and minutes cycled was highest early in the intervention and less towards the end of the intervention period. A significant improvement in VO_2 max were associated with cycled distance. When participants were stratified based on initial VO_2 max, only participants with low VO_2 max experienced improvement associated with cycled distance.

With a provided E-bike, both Geus et al.[24] and Fyhri and Fearnley [20] observed higher self-reported cycled distance, in their interventions studies conducted over six weeks and three months, respectively, compared to the present study. The corresponding values were 15.5 km/day and 68 km/week measured by travel diary, while in the first three months of the present study the participants cycled 47 km/week measured with a GPS. As previous data has indicated, self-reported data on active travel may be more likely to overestimate compared to GPS [27]. Although GPS data might be more prone to signal noise or signal loss from satellites [28]. Furthermore, the sample characteristics of Fyhri and Fearnley was different (Norwegian adults, 30 % women) from the sample of Geus et al. [24] (Belgian adults, non-commuters, 50 % women) and the present study. Also, the intervention period in the present study began in September, while the intervention of Fyhri and Fearnley began in July. Logically, the differences in aspects such as geographic, seasonal variance of the intervention and characteristics of the sample can influence cycled distance with an available E-bike. Another inequality worth emphasizing is that the participants in the study of Geus et al. [24] were encouraged to cycle for at least three times a week, in which were not the case in the present study, neither in the study of Fyhri and Fearnley [20]. Compared to conventional bicycle, Piwek and colleges found in 13 highly motivated students, that a provided with a conventional bicycle and a cycle computer, resulted in 109 km during a total of five weeks, corresponding to 21.8 km/week, which is considerable lower than was observed in the present study of inactive working adults with access to an E-bike [29].

In the present study, a reduction in cycled distance from autumn to spring was observed, which might be explained by participants' adherence to the GPS measurement protocol. In a systematic review by Krenn et al. [28], it became apparent that a major cause of GPS loss was participants' compliance to the measurement protocol. Furthermore, the findings showed that loss of GPS data were highly correlated ($r = 0.80$) with measurement period [28]. Another explanation can be that participants did not maintain the cycling behaviour, due to lack of motivation over time. It is also worth mentioning that the noticeable drop observed around Christmas in the winter season and Easter in the spring season, may have contributed to a stronger reduction in cycled distance overall.

In contrast to our findings, Geus et al. found no change in VO_2 max after six weeks [24], which may reflect on the difference in intervention period, as the present study investigated a period of eight months, whereas Geus et al. investigated a period of six weeks [30].

Compared to an intervention study on conventional bicycles, Møller et al. found, in a randomised controlled trial, an improvement of 7.8 % in VO_2 max after cycling 403 km during an eight weeks period [31]. The cycled distance was considerably higher than what was found in the present study. However, similar to other intervention studies [32, 33], the participants in the study of Møller et al. [31] were instructed to cycle for å minimum amount per day.

As previous research have established, high fit individuals have a lower relative intensity at submaximal workloads than low fit individuals [34], meaning that a specific activity may be of vigorous intensity for individuals with initial low VO_2 max , yet moderate intensity for individuals with higher VO_2 max [35]. Furthermore, previous studies indicate that intensity of physical activity can be influenced by the selected assistance setting [15] and velocity [16] when E-biking. Therefore, it may be reasonable to assume that the high fit group in the present study need to cycle a greater amount or choose a more vigorous intensity of cycling activity, than the participants in the low fit group to achieve improvements in VO_2 max. Again, the high fit group did cover a greater mean cycled distance (43.8 km/week) than in the low fit group (36.1 km/week) although no significant differences were observed. It is important to emphasize, that only five participants had VO_2 max above predicted value resulting in limited power in the stratified analysis.

An improvement of 7.7 % (2.4 ml/kg/min) in VO_2 max was found, where the greatest improvement of 9.6 % (2.9 ml/kg/min) was seen in the low fit group. Although this may appear small, findings from a meta-analysis indicated that even 3.5 ml/kg/min increase in VO_2 max resulted in a risk reduction of 13% for mortality and 15% of cardiovascular diseases [36]. In the present study, an increase in the time to exhaustion was found in the low fit group, which may be seen in relation to a study of Blair et al. [37], who used time to exhaustion as a measure of cardiopulmonary fitness. The findings suggested that a 1-minute increase in time to exhaustion, with the original Balke protocol, was associated with a risk reduction of 7.9 % for all-cause mortality [37]. Indeed, since the protocol used in the present study was modified with larger increments, thus designed to lead to exhaustion in less time than the original Balke protocol [38], it is reasonable to assume that a 1-minute increase in time to exhaustion might lead to an even greater risk reduction.

Strengths and limitations

Over an extended period, the present study used direct measurements of VO_2 max and objectively assessments of bicycle use with a GPS, which represents measurements of high validity. The main advantage of using GPS is the ability to navigate actual travel routes taken, in contrast to commonly used self-reported and estimation based on geographical information systems [39]. However, the findings must be interpreted with caution with respect to the study's limitations. Some participants noted technical difficulties when uploading GPS data online, as well as difficulties to maintain continuous GPS signal while cycling, which can have caused an underestimation of cycled distance. Other reported technical issues such as battery capacity, participant adherence and signal loss should also be taken under consideration [28]. In addition, the present study has a relative small sample size and without a control group, we can only examine associations, without the ability to draw causal relationships. Furthermore, familiarization of the test procedure at baseline might have contributed to an increase of VO_2 max at post test.

To the authors knowledge this is the first study to objectively evaluate cycled distance when giving access to an E-bike and the association between cycled distance and changes in VO_2 max over an extended period. These findings might be considered as exploratory and may function as a knowledge basis for further research, preferably with a larger samples size and using a randomized controlled design.

Conclusion

The intervention including access to an E-bike over eight months resulted in weekly cycling of 37.6 km. Average 7.7 % improvements in cardiopulmonary fitness were observed, in which were associated with cycled distance. The findings indicate that E-bikes may contribute to mobilize inactive individuals to initiate transport-related physical activity.

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Table and figure legends

Table 1: Characteristics of study participants, presented as mean and standard deviation (SD) in parentheses or number and percent in parentheses.

Table 2: Characteristics of bicycle use from GPS measurements during the intervention period.

Table 3: Physiological outcomes from VO_2 max tests (Pre and Post) for maximal oxygen uptake (VO_2 max), time to exhaustion, heart rate (HR), respiratory exchange rate (RER), minute ventilation (V_E) and reported perceived exertion (RPE) presented as mean (95% CI) of highest test values (peak). N = 21 unless otherwise stated [a, b].

Figure 1:
Cycling distance per week, stratified by season (Mean and SD). N = 20.
* Significantly different from Autumn, at significant level < 0.05.

Figure 2:
Weekly cycling distance. Mean kilometres cycled per calendar week. N = 20.

Figure 3:
VO_2 max (3a) and test time (3b) at baseline (pre) and after the intervention (post) presented by level of initial cardiopulmonary fitness (VO_2 max) (mean ± 95%CI).

Figure 4:
Changes in VO_2 max presented as percentage and weekly cycling in km after transforming into logarithms. Stratified by low fit (filled circles) and high fit (empty circles). N = 18. Line of regression without stratification.

Table 1

	Women (n = 18)	Men (n = 7)
	Mean (SD)	**Mean (SD)**
Age	43 (7)	48 (6)
Height (cm)	171.5 (5.4)	185 (7.5)
Weight (kg)	74.5 (7.9)	102 (21.6)
BMI ($kg \cdot m^{-2}$)*	25.4 (12.3)	28.7 (15.8)
Distance to work (km)		
Workplace	11 (3.8)	10 (1.4)
Grocery store (km)	1.9 (1.5)	1.4 (0.5)
Kindergarten (km)	2.9 (2.3)	1.4 (0.5)
Center of the city (km)	5 (3.5)	7.4 (3.1)
Participants below predicted VO_2max (low fit), n (%)	11 (61)	6 (86)
Part time employed, n (%)	2 (11)	0 (0)
Using car/moped to work, n (%)	14 (77.8)	6 (85.7)
Using public transport to work, n (%)	4 (22.2)	1 (14.3)
Educational level, n (%)		
Less than high school	2 (11)	1 (14)
High School	3 (17)	1 (14)
University/college < 4 yrs.	3 (17)	0 (0)
University/college ≥ 4 yrs.	10 (56)	5 (71)
Current smoker, n (%)	3 (17)	0 (0)
Married or live in partner, n (%)	15 (83)	7 (100)

n (%) = Number (percent). BMI = Body Mass Index. *Presented with median and interquartile range.

Table 2

	Weekly characteristics (n = 21)	**Daily characteristics (n = 20)**	
		Week days	Weekend days
Distance (km)	37.6 (24.0)	7.1 (4.5)	0.9 (0.4)**
Time (min)	107 (62)	20 (12)	3 (1)**
Elevation gain (m)	591 (603)	114 (124)	14 (21)**
Average speed (km/h)	20.4 (3.9)	20.6 (3.5)	18.9 (3.8)[a]

Weekly characteristics = mean (SD) per week.
Daily characteristics = mean (SD) per day.
Week days = Monday to Friday.
Weekend days = Saturday to Sunday.
** = significant different from week days at level <0.01.
[a] N = 13 participants

Table 3

	Pre	**Post**	***P***
VO_2 max (ml/kg/min)	34.1 (31.6, 36.7)	36.5 (34.4, 38.6)	**< 0.001**
Time to exhaustion (min)	11.4 (10.5, 12.4)	12.5 (11.4, 13.6)	0.069
HR peak (bpm/min)[a]	181 (175, 187)	180 (174, 186)	0.429
RER peak (VO_2/VCO_2)[b]	1.27 (1.21, 1.32)	1.25 (1.20, 1.30)	0.272
V_E peak (l/min)[b]	119.2 (106.2, 132.2)	119.8 (104.5, 134.7)	0.755
RPE peak (Borg 7 – 20)[b]	17.8 (17.0,18.6)	18 (17.3,18.7)	0.385

Pre = test at baseline. Post = test at the end intervention period. Statistical significance is presented in bold. Statistical significance are presented in bold.
[a] N = 18.
[b] N = 14.

Figure 1

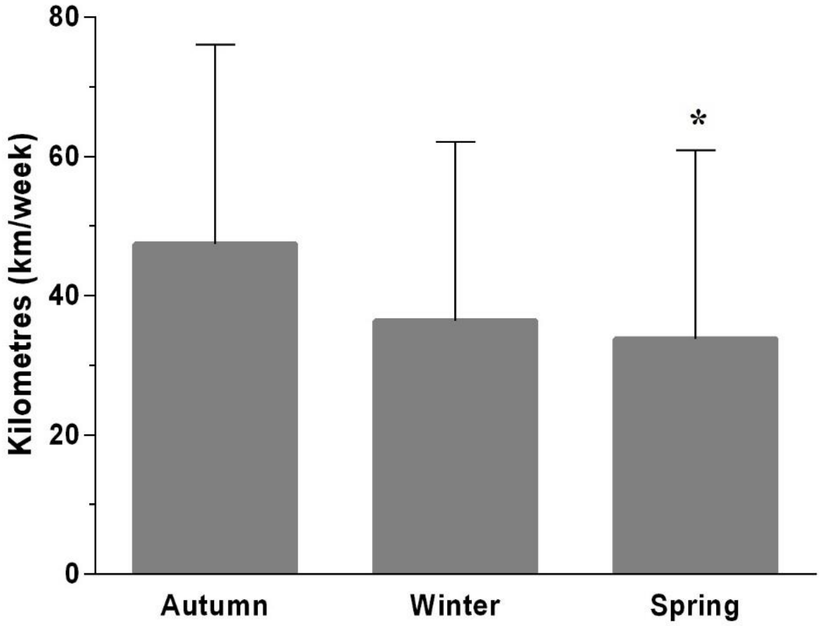
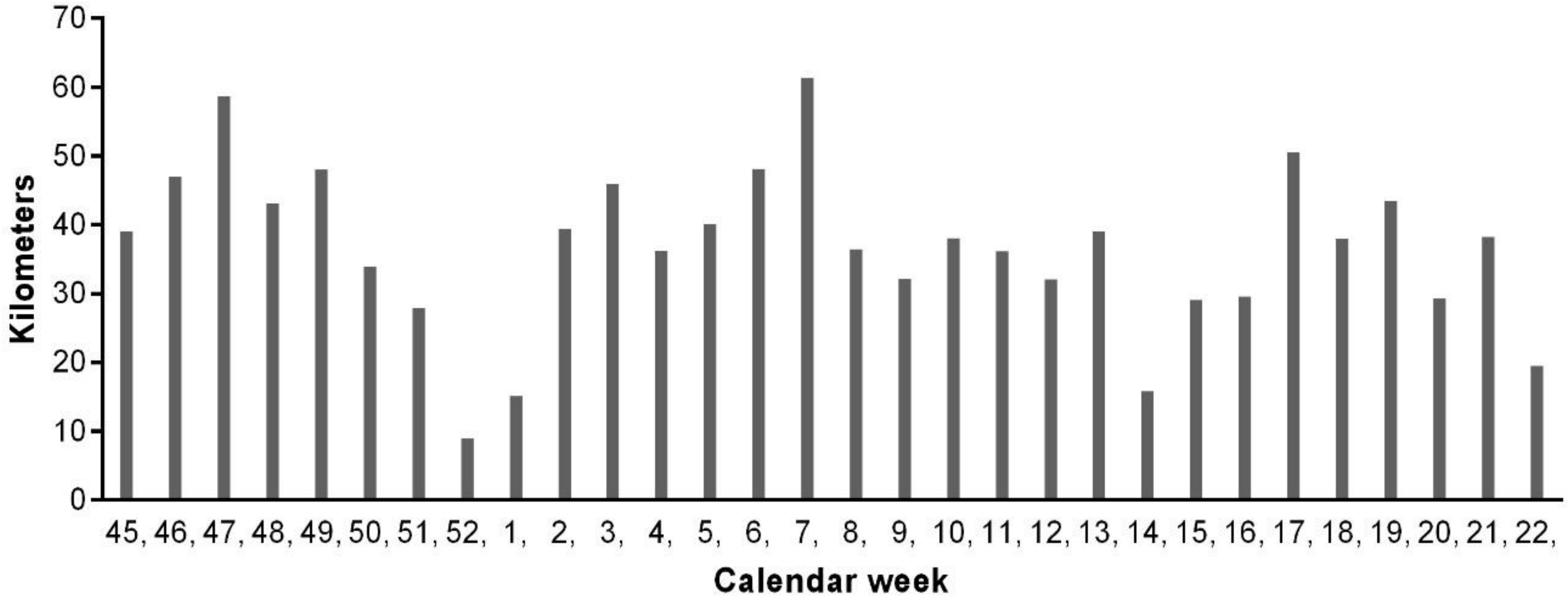


Figure 2



Kilometers
70
60
50
40
30
20
10
0
45, 46, 47, 48, 49, 50, 51, 52, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22,
Calendar week

Figure 3

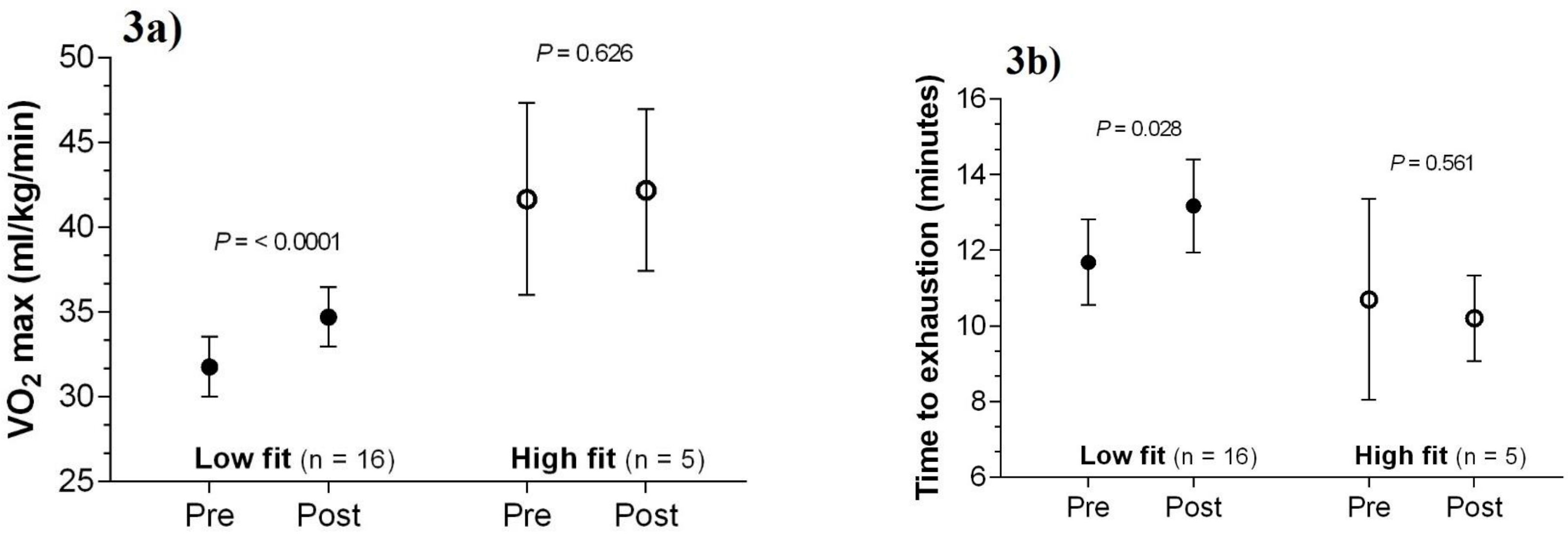
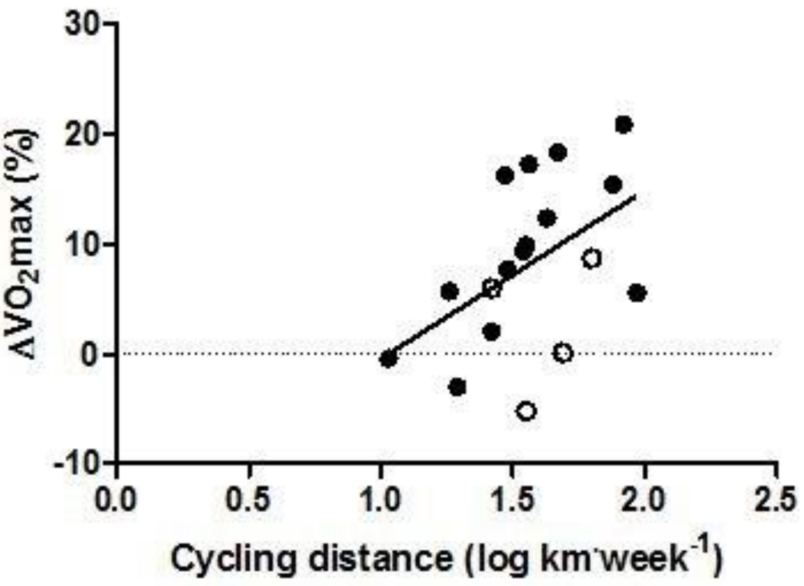

3a)
VO2 max (ml/kg/min)
50
45
40
35
30
25
P = < 0.0001
P = 0.626
Low fit (n = 16)
High fit (n = 5)
Pre
Post
Pre
Post
3b)
Time to exhaustion (minutes)
16
14
12
10
8
6
P = 0.028
P = 0.561
Low fit (n = 16)
High fit (n = 5)
Pre
Post
Pre
Post

Figure 4



30
20
10
0
-10
ΔVO2max (%)
0.0
0.5
1.0
1.5
2.0
2.5
Cycling distance (log km·week-1)

Appendix B – Contract for disposal of the E-bike (location 1)

UNIVERSITETET I BERGEN
Institutt for global helse og samfunnsmedisin

Avtale om lån av elsykkel i forskningsprosjekt

Avtale mellom
Deltaker (elsykkelbruker) :
Og forskningsprosjekt elsykkel UiB

Service og bruk
Deltaker forplikter seg til at el-sykkel bruker får daglig vedlikehold og renhold etter instruksjon fra sykkelleverandør, BoA Sykler. Bruker er også ansvarlig for at el-syklene leveres til BOAsykler hver 2. måned for sjekk og service. Dersom det oppdages noen feil eller mangler skal dette meldes prosjektleder og evt kontakte leverandør for utbedring. Evt. punkteringer må utbedres av bruker. Om brukers vedlikehold ikke utføres på forsvarlig vis, kan el-sykkelen måtte leveres tilbake til prosjektleder. Dette vil også tre i kraft dersom elsykkelen ikke er i bruk over en 2 ukers periode eller ikke over tid brukes 3 eller flere turer per uke.

Retningslinjer sikring av el-sykkel og GPS enhet i leieperioden
El-sykkelen skal, når den ikke er i bruk, lagres under tak på avlåst område. Under lagring skal display (hvis avtagbart) separeres fra sykkelen for å minske risiko for tyveri. Bakhjulslås og forsikringsgodkjent lås skal alltid brukes til å feste sykkelen til et fast punkt. Medfølgende GPS skal likeledes sikres slik at den enten er under tilsyn eller innelåst.

Ansvar og forsikring
Bruker er ikke ansvarlig for skader/feil forbundet med vanlig slitasje eller feil som omfattes av vanlige reklamasjonsårsaker. Bruker må fylle ut skademelding ved skade og rapportere tyveri til politiet. Tyveri eller skade som skyldes uaktsomhet eller uautorisert bruk vil medføre at bruker må erstatte tapet i ved at sykkelen må bringes tilbake i fullverdig stand. Aldersgrense for å bruke av utleid el-sykkel er 18 år. Skader ved transport til jobb utløser normalt ikke rettigheter som yrkesskade. Bruker oppfordres til å avklare om han/hun har forsikringsdekning for transport til jobb.

Prosjektleder

Elsykkelbruker

Prosjektleder Bergen
Førsteamanuensis
Thomas Mildestvedt
Universitetet i Bergen
Institutt for global helse og samfunnsmedisin
Thomas.Mildestvedt@igs.uib.no

Postadresse
IGS
Postboks 7804
5020 Bergen

Telefon 55 58 00 00
Postmottak@uib.no
Internett www.uib.no/
Org no. 874 789 542

Telefon 55 58 61 00
Telefaks 55 58 61 30

Besøksadresse
Kalfarveien 31
Bergen

Appendix C – Contract for participation in the study (location 2)

KONTRAKT OM DELTAKELSE I PROSJEKT

MELLOM

____
(heretter benevnt som deltakende bedrift)

OG

UNIVERSITETET I AGDER
(heretter benevnt universitetet)

1. Beskrivelse av prosjektet
Prosjektets tittel er «Elsykkelpilot - Gir regelmessig elsykling relevante helseeffekter for individ og befolkning?». Prosjektet er beskrevet i vedlegg 1 (prosjektskisse).

2. Kontraktsperiode og fremdriftsplan
Prosjektperiode er fra oktober 2014 til juli 2015.

3. Prosjektansvarlig
Prosjektansvarlig er førsteamanuensis Sveinung Berntsen Stølevik ved Fakultet for Helse og idrettsvitenskap, Institutt for Folkehelse, Idrett og Ernæring.

4. Økonomi og betalingsbetingelser
Deltakende bedrift betaler kr 40 000 (10 000/deltaker) for deltakelse i prosjektet. Universitetet vil fakturere beløpet forskuddsvis (hele beløpet), med første fakturering 01.11.2014.
Ved betalingsforsinkelse påløper renter i henhold til morarenteloven. Evt. mva. kommer i tillegg dersom dette ikke er spesifisert.

5. **Publisering**
Universitetet og den enkelte prosjektmedarbeider kan publisere generelle vitenskapelige resultater fra prosjektet.

6. Ansvar
Universitetet er ansvarlig for den faglige og praktiske gjennomføring av prosjektet. Universitetet fraskriver seg et hvert økonomisk ansvar dersom arbeidet ikke skulle føre frem til de forventede resultater. Universitetet svarer ikke for tap som følge av avbrudd eller forsinkelse på grunn av sykdom o.l. årsaker.

7. Hemmeligholdelse
All informasjon om deltakende bedrifts forretningsforhold o.l. som høgskolen i løpet av prosjektperioden får kunnskap til og som ikke er offentlig kjent, skal behandles konfidensielt inntil deltakende bedrifts har gitt melding om det motsatte.

8. Eiendomsrett til utstyr

Alt utstyr som anskaffes ifm utførelsen av prosjektet blir vederlagsfritt universitetets eiendom. Utstyr som lånes ut av Universitetet plasseres i universitetet på deltakende bedrifts risiko.

9. Oppsigelse
Hver av partene kan si opp/trekke seg ut av prosjektet med 3 måneders skriftlig varsel.

Hver enkelt prosjektdeltaker kan når som helst trekke seg fra prosjektet uten å oppgi grunn (som beskrevet i informasjonsskriv og som prosjektdeltakerne har undertegnet). Utstyr skal da leveres tilbake til universitet snarest.

10. Mislighold
Dersom en av partene misligholder sine forpliktelser etter denne kontrakten, kan den annen part kreve prosjektet stanset med 2 måneders skriftlig varsel.

Dersom deltakende bedrift misligholder kontrakten, svarer han for alle utgifter i forbindelse med en hensiktsmessig avvikling av arbeidet. Dette gjelder også utgifter i tilknytning til de forpliktelser universitetet har i forhold til tilsatte ved prosjektet.

Dersom universitetet misligholder kontrakten, er deltakende bedrifts ikke ansvarlig for utgifter som påløper etter oppsigelsesfristens utløp. Universitetet er ikke ansvarlig for konsekvenstap.

11. Force Majeure
Ingen av partene har misligholdt sine forpliktelser etter denne kontrakten dersom utførelsen av pliktene er blitt utsatt eller forhindret av force majeure. Varsel om force majeure skal skje uten ugrunnet opphold.

12. Tvister
Tvister som gjelder forståelsen av denne kontrakten, eller forhold som utspringer av kontrakten, skal søkes løst ved forhandlinger mellom partene. Dersom enighet ikke oppnås, skal tvisten avgjøres med endelig virkning ved voldgift etter reglene i rettergangslovens, kap. 32.

Denne kontrakt er utferdiget i 2 eksemplarer, ett til hver av partene.

For Universitetet i Agder:	For deltakende bedrift:
______________________ (sted/dato)	______________________ (sted/dato)
______________________ Prosjektansvarlig	______________________ (signatur)
______________________ Adm. leder	

Appendix D – Consent form

UNIVERSITETET I BERGEN
Institutt for global helse og samfunnsmedisin

UNIVERSITETET I AGDER
FAKULTET FOR HELSE- OG IDRETTSVITENSKAP

Universitetet i Stavanger

Til aktuelle deltakere i prosjektet «jobbsykling»

Her følger litt informasjon til deg som du må vurdere og samtykke til for å kunne delta i studien. Det er fint om du leser informasjonen og tar stilling til om dette kan passe for deg.

Bakgrunn og hensikt

Målet med studien er å finne ut om elsykkel kan øke andelen jobbyklister og om elsykling kan gi viktige helseeffekter for den enkelte og for befolkningen.

Universitetet i Bergen er ansvarlig for forskningsstudien og samarbeider med Universitetet i Stavanger og Universitetet i Agder.

Hvem kan være med?

Alle ansatte, med minimum 3 km reisevei, som ønsker å komme i gang med aktiv transport med sykkel til jobb, som foreløpig ikke benytter aktiv transport og som ikke driver regelmessig utholdenhetstrening (over 30 minutter mer enn 2 dager pr uke med høy intensitet) inviteres til å delta i studien.

Hva innebærer studien?

I undersøkelsen følges en gruppe elsyklister i 3-12 mnd etter avtale med den enkelte deltaker.

Som deltaker i forskningsprosjektet ber vi deg fylle ut spørreskjema og det vil bli gjennomført fysiske tester som kartlegger din situasjon ved start og ved avslutning av studien.

Spørreskjemaet tar ca. 15 minutter å besvare.

Du vil få tilgang til en GPS-sykkelcomputer for nøyaktig rapportering av sykkelaktivitet. Data fra sykkelcomputeren lastes opp til en nettbasert treningsside, Garmin Connect en gang pr uke. Du vil få opplæring i bruk av sykkelcomputeren. Prosjektleder vil ha tilgang til dine sykkeldata i prosjektperioden.

De fysiske testene består i måling av blodtrykk, vekt, og midjemål, samt maksimalt oksygenopptak. Maksimalt oksygenopptak måles ved at man går på tredemølle/og eller sykler på ergometersykkel til man ikke orker mer mens man puster i en maske. Underveis måles forbruk av oksygen. Dette gir et godt mål på hvilken kondisjon du har og på din generelle helsetilstand.

Du vil kunne bli spurt om dybdeintervjuer for å høre dine synspunkter på bruk av sykkel som transportmiddel. Et intervju tar typisk en time og gjennomføres enten i gruppe eller individuelt. Det vil bli innhentet eget samtykke til å delta i en denne delen av undersøkelsen.

Hva skjer med informasjonen om deg?

Testene av deg og informasjonen som registreres om deg skal kun brukes slik som beskrevet i hensikten med studien. Alle opplysninger vil bli behandlet uten navn og fødselsnummer eller andre direkte gjenkjennende opplysninger. En kode knytter deg til dine opplysninger og tester gjennom en navneliste. Det er kun autorisert personell knyttet til prosjektet som har adgang til navnelisten og som kan finne tilbake til deg. Personidentifiserbar informasjon vil bli lagret i inntil 5 år. Det vil ikke være mulig å identifisere deg når resultatene av studien publiseres.

Postadresse
IGS
Postboks 7804
5020 Bergen

Telefon 55 58 00 00
Postmottak@uib.no
Internett www.uib.no/
Org no. 874 789 542

Telefon 55 58 61 00
Telefaks 55 58 61 30

Besøksadresse
Kalfarveien 31
Bergen

Opplysninger i Garmin Connect inneholder data om hvor og hvor langt du har syklet. Etter prosjektets avslutning velger du selv om du vil beholde dine data eller om de skal slettes. Du kan selv endre passord slik at prosjektleder ikke lenger har tilgang til dine data.

Risiko og forsvarlighet

Transport i trafikken mellom arbeidssted og jobb medfører generelt risiko for skade. Vi oppfordrer alle deltakere til å avklare om de har forsvarlig forsikringsdekning ved eventuelle ulykker. Skader ved reise til jobb regnes ikke som yrkesskade. Forskningsprosjektet tar ikke ansvar for eventuelle skader som måtte oppstå i forbindelse med prosjektdeltakelsen. Dersom deltaker ønsker personlig forsikring kan dette dekkes av forskningsprosjektet etter søknad fra deltaker.

Frivillig deltakelse

Det er frivillig å delta i studien. Dersom du ønsker å delta, undertegner du samtykkeerklæringen i 2 eksemplarer. Du kan når som helst og uten å oppgi noen grunn trekke ditt samtykke til å delta i studien. Dersom du senere ønsker å trekke deg eller har spørsmål til studien, kan du kontakte lokal prosjektansvarlig.

Samtykke til å delta i studien

Jeg er villig til å delta i studien

(Signert av prosjektdeltaker, dato)

Jeg bekrefter å ha gitt informasjon om studien.

(Signert, forskningsprosjektmedarbeider, dato)

Stavanger	**Kristiansand**	**Bergen**
Forsker, MD	**Førsteamanuensis**	**Førsteamanuensis**
Stian E. Lobben	**Sveinung Berntsen Stølevik**	**Thomas Mildestvedt**
Universitetet i Bergen	**Universitetet i Agder**	**Universitetet i Bergen**
Institutt for global helse og samfunnsmedisin	**Institutt for folkehelse, idrett og ernæring**	**Institutt for global helse og samfunnsmedisin**
stianlobben@gmail.com	**Sveinung.Berntsen@uia.no**	**Thomas.Mildestvedt@igs.uib.no**
Tlf 99005743		

Appendix E – Approval from ethics committee

REK
REGIONALE KOMITEER FOR MEDISINSK OG HELSEFAGLIG FORSKNINGSETIKK

Region:	Saksbehandler:	Telefon:	Vår dato:	Vår referanse:
REK vest	Øyvind Straume	55978496	21.10.2014	2014/603/REK vest
			Deres dato:	**Deres referanse:**
			19.10.2014	

Vår referanse må oppgis ved alle henvendelser

Thomas Mildestvedt

Institutt for global helse og samfunnsmedisin

2014/603 Jobbsykling- elsykkel

Forskningsansvarlig: Universitetet i Bergen
Prosjektleder: Thomas Mildestvedt

Vi viser til epost med supplerende informasjon av 16.10.2014 og søknad om prosjektendring datert 19.10.2014 for ovennevnte forskningsprosjekt. Søknaden er behandlet av leder for REK vest på fullmakt, med hjemmel i helseforskningsloven § 11.

Vurdering

Omsøkt endring
Prosjektendringen innebærer en endring av design til en pilotstudie med en enkelt arm (elsykkel). Videre er det søkt om endring av prosjektslutt til 30.11.2014, og informasjonsskrivet er revidert med klargjøring av prosedyre i forbindelse med forsikring.

Vurdering
REK vest har ingen innvendinger til endring i design til en kohort. Når det gjelder prosjektslutt så antar vi at dette er en trykkfeil siden prosjektleder har satt i protokollen at deltakerne skal følges i 3-12 måneder. Vi setter derfor prosjektslutt til 30.11.2015.

Forsikring
Vi beklager at denne problemstillingen ikke ble tatt opp ved førstegangsbehandling av prosjektet.

Det er REK vest sin oppfatning at det ikke er tilstrekkelig å peke på staten som selvassurandør i dette prosjektet. Det er forskningsansvarlig institusjon sin plikt at det foreligger nødvendig forsikring av forskningsdeltakere, og dette prosjektet har en absolutt reell risiko for skade.

I den reviderte forespørselen til deltaker legger prosjektleder opp til at deltakerne kan søke om å få dekket en privat forsikring. I epost av 14.10.2014 utdypes dette ved at kriteriet er at deltakerne kan dokumentere kostnaden på en forsvarlig tilleggsforsikring. Dette er en fornuftig fremgangsmåte og et rimelig krav, men REK vest setter som vilkår at eventuelle ikke-forsikrete personer ikke inkluderes i studien.

Vilkår

- Relevant forsikring settes som et inklusjonskriterie i studien.

Vedtak

REK vest godkjenner prosjektet på betingelse av at ovennevnte vilkår tas til følge.

Klageadgang
Du kan klage på komiteens vedtak, jf. forvaltningslovens § 28 flg. Klagen sendes til REK vest. Klagefristen er tre uker fra du mottar dette brevet. Dersom vedtaket opprettholdes av REK vest, sendes klagen videre til Den nasjonale forskningsetiske komité for medisin og helsefag for endelig vurdering.

Med vennlig hilsen

Ansgar Berg
Prof. Dr.med
Komitéleder

Øyvind Straume
sekretariatsleder

Kopi til: *post@uib.no*

Appendix F – Baseline questionnaire

Spørsmål til deltakere i ELsykkelprosjektet

I ☐ skal det settes et kryss (×) eller en hake (v) mens en skriver inn tall på felt markert med ________

- **Kjønn:** (1) ☐ Kvinne (2) ☐ Mann
- **Alder:** _____ år
- **Sivil stand:** (1) ☐ Enslig (2) ☐ Samboende/gift
- **Hvilken utdanning er det høyeste du har fullført?**
  (1) ☐ Grunn skole 7-10 år
  (2) ☐ 1-2 år videregående- eller yrkesskole
  (3) ☐ Videregående skole med studiekompetanse
  (4) ☐ Høgskole/Universitet, mindre enn 4 år
  (5) ☐ Høgskole/Universitet, 4 år eller mer
- **Hvor høy var husholdningens samlede bruttoinntekt siste året. Ta med inntekt fra arbeid, trygder, sosialhjelp og lignende.**
  (1) ☐ Under 201.000 kr
  (2) ☐ 201.000-300.000 kr
  (3) ☐ 301.000-400.000 kr
  (4) ☐ 401.000-550.000 kr
  (5) ☐ 551.000-700.000 kr
  (6) ☐ 701.000-850.000 kr
  (7) ☐ over 850.000 kr
- **Hva er din hovedaktivitet?**
  (1) ☐ Yrkesaktiv heltid (2) ☐ Yrkesaktiv deltid
- **Har du røykt/ Røyker du daglig?**
  (1) ☐ Ja, nå (2) ☐ Ja, tidligere men sluttet i (sluttår): ______ (3) ☐ Aldri
- **Hvor langt er det fra hjemmet ditt til?** Fyll inn antall hele km, for eksempel «4»
  (1) Arbeidsplassen/studiestedet ____
  (2) Barnehagen/skolen (dersom har barn i barnehage/skole) ____
  (3) Nærmeste matvarebutikk ____
  (4) Nærmeste sentrum ____
- **Har du egen sykkel?**
  (1) ☐ Ja
  (2) ☐ Nei
- **Har du el-sykkel?**
  (1) ☐ Ja
  (2) ☐ Nei

Spørsmål til deltakere i ELsykkelprosjektet

I ❑ skal det settes et kryss (×) eller en hake (v) mens en skriver inn tall på felt markert med ________

- **Hvor mange dager i uka er du på jobb/skole (ikke hjemmekontor)? _______ dager/uke**

- **Hvordan kommer du deg som oftest til og fra i <u>sommerhalvåret</u> når du?**

	Til fots	Sykkel/el-sykkel	Bil/motorsykkel /moped/skuter	Offentlig transport	Ikke aktuelt
Skal på jobb/studere	(1) ❑	(2) ❑	(4) ❑	(5) ❑	(6) ❑
Handler matvarer	(1) ❑	(2) ❑	(4) ❑	(5) ❑	(6) ❑
Handler andre varer	(1) ❑	(2) ❑	(4) ❑	(5) ❑	(6) ❑
Transporterer deg selv på fritiden	(1) ❑	(2) ❑	(4) ❑	(5) ❑	(6) ❑
Transporterer barn til/fra barnehage/skole	(1) ❑	(2) ❑	(4) ❑	(5) ❑	(6) ❑
Transporterer barn eller andre til/fra fritidsaktiviteter	(1) ❑	(2) ❑	(4) ❑	(5) ❑	(6) ❑

- **Hvordan kommer du deg som oftest til og fra i <u>vinterhalvåret</u> når du?**

	Til fots	Sykkel/el-sykkel	Bil/motorsykkel /moped/skuter	Offentlig transport	Ikke aktuelt
Skal på jobb/studere	(1) ❑	(2) ❑	(4) ❑	(5) ❑	(6) ❑
Handler matvarer	(1) ❑	(2) ❑	(4) ❑	(5) ❑	(6) ❑
Handler andre varer	(1) ❑	(2) ❑	(4) ❑	(5) ❑	(6) ❑
Transporterer deg selv på fritiden	(1) ❑	(2) ❑	(4) ❑	(5) ❑	(6) ❑
Transporterer barn til/fra barnehage/skole	(1) ❑	(2) ❑	(4) ❑	(5) ❑	(6) ❑
Transporterer barn eller andre til/fra fritidsaktiviteter	(1) ❑	(2) ❑	(4) ❑	(5) ❑	(6) ❑

Appendix G – Participant's manual and protocol of GPS measurement

Oppstart:

1. Sett deg ved PCen du regner med å ville bruke til opplasting av Garmindata.
2. Gå til adressen "connect.garmin.com" i din nettleser.
3. Trykk på den blå "kom i gang"-knappen midt på skjermen og følg stegene du føres gjennom.
4. Pakk ut GPS fra esken og koble til PC med USB-kabel. GPSen lades og du vil kanskje få tilbud om synkronisering av nyeste programvare. Takk ja. Får du ikke slikt tilbud, ta livet med ro.
5. Når GPSen er fulladet er den klar til bruk.

Sykkeltur:
1. Fest brakett på styret.
2. Fest GPS i braketten.
3. Skru på GPS
4. Trykk start
5. Sykle
6. Trykk stopp når du er fremme/hjemme. (computeren holder selv styr på småpauser underveis i turen)

Opplasting av data/lading:
Bør gjøres ukentlig eller oftere
1. Sjekk at "Garmin express" er startet på PC
2. Koble GPS til PC med USB-kabel og data lastes automatisk opp.
3. Svar ja når du får tilbud om å se på aktivitetene som er lastet opp, evt logg inn i connect.garmin.com hvis du ikke får slikt tilbud.
4. Øverst til venstre ser du 3 hvite horisontale linjer over hverandre - trykk på disse - velg så fanen "aktiviteter".
5. Når du står i aktivitetsbildet velger du knappen "Hurtigredigering" øverst til venstre
6. I kolonne nr 5 fra venstre kan du velge "hendelsestype". Marker alle jobbreiser med hendelsestype "Transport".

Du kan gi turene navn, spesifisere sykkeltype, velge andre hendelsestyper osv i dette bildet. Det trenger du ikke gjøre for forskningsprosjektets del, men du står fritt til å gjøre det om du ønsker.

Ta gjerne kontakt med din kontakt i prosjektet om du står fast.