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# Is there an association between total physical activity level and $VO_{2max}$ among fitness club members?

A prospective one-year follow-up study

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# ABSTRACT

**BACKGROUND:** Since Cardiorespiratory fitness (CRF) is an important predictor for all-cause mortality, it is vital to know if meeting the global physical activity (PA) recommendations of 150 minutes of moderate-to-vigorous PA (MVPA) weekly is associated with higher levels of the gold standard measure of CRF: Maximal oxygen uptake ($VO_{2max}$). The majority of former research has investigated this association in the general adult population, and has used self-reporting of PA level. Self-reported PA increases the chance of over-reporting PA level, which device-measured PA does not. To this date, no studies have investigated the association between device-measured PA and $VO_{2max}$ in a fitness club setting. Thus, the aims of this present study were to investigate if there was an association between device-measured PA and $VO_{2max}$, and if a non-exercise model could predict $VO_{2max}$ among untrained adults at membership start-up and after one year of fitness club membership. **METHOD:** This master thesis was part of the research project: “Fitness clubs – a venue for public health?” a longitudinal prospective study. At membership start-up, 125 untrained new fitness club members were recruited for the study. PA level was measured with ActiGraph GT1M for seven constructive days, and $VO_{2max}$ was measured with a cardiopulmonary exercise test using the stepwise modified Balke protocol at membership start-up (n = 125) and at one-year follow-up (n = 61). A Pearson correlation was assessed for minutes in MVPA and $VO_{2max}$, as well as total counts per minute (cpm) and $VO_{2max}$. To assess for potential covariates, and to develop a non-exercise model, a multivariable regression analysis including six factors: minutes in MVPA, total cpm, body mass index (BMI), fat mass%, age and gender with $VO_{2max}$ ($mL \cdot kg^{-1} \cdot min^{-1}$), as a dependent factor, was calculated at both time points. **RESULTS:** At membership start up, time spent in MVPA and total cpm was significantly associated with $VO_{2max}$ in both genders (bivariate correlation coefficient r=.259, p=.002 and r=.275, p=.001, respectively), but not at follow-up (r=.123, p=.173 and r=.198, p=.063). When adjusting for covariates (gender, fat mass%, age and BMI), no association was found between MVPA and cpm with $VO_{2max}$ at membership start-up (p=.83 and p=.08) or at follow-up (p=.527 and p=.164), respectively. The non-exercise model explained 69% and 58.8% of variance in measured $VO_{2max}$ ($mL \cdot kg^{-1} \cdot min^{-1}$) at membership start-up and at follow-up (p<.001). Age, gender and fat mass% were the strongest predictors explaining $VO_{2max}$. **CONCLUSION:** Device-measured PA was significantly associated with $VO_{2max}$ at membership start-up, but not at 1-year follow-up. The non-exercise model may be a feasible tool for rough estimate of $VO_{2max}$ among healthy and untrained fitness club members.

# CONTENTS

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# ABBREVIATIONS

| | |
|---|---|
| **BMI** | Body Mass Index (kg/$m^2$) |
| **CI** | Confidence Interval |
| **CPET** | Cardiopulmonary Exercise Test |
| **CPM** | Counts Per Minute |
| **CRF** | Cardiorespiratory Fitness |
| **SEE** | Standard Error of Estimate |
| **FAT MASS%** | Fat percentage |
| **IPAQ** | The International Physical Activity Questionnaire |
| **MET** | Metabolic Equivalent of Tasks |
| **$mL/kg^{-1}/min^{-1}$** | Milliliters of oxygen per kilogram of body weight |
| **MVPA** | Moderate-To-Vigorous Physical Activity |
| **N** | Total number of participants |
| **NCDs** | Noncommunicable Diseases |
| **PA** | Physical Activity |
| **RER** | Respiratory Exchange Rate |
| **$R^2$** | The multiple coefficient of determination |
| **SD** | Standard Deviation |
| **$VO_{2max}$** | Maximal Oxygen Uptake |
| **$VO_{2peak}$** | Peak Maximal Oxygen Uptake |
| **WHO** | Worlds Health Organization |

# 1. BACKGROUND

The pandemic growth of physical inactivity has been identified as the fourth leading risk factor for global mortality, and is associated with numerous non-communicable chronic diseases (NCDs) and premature death (WHO, 2018). Worldwide, 1.6 million deaths annually due to NCDs, can be attributed to insufficient physical activity (PA) (WHO, 2018). Inactivity also represents an economic burden for society, and is estimated to cost annually around 67.5 billion dollars globally in health care expenditures and illness-related absence (Ding et al., 2016). Though, despite the public health authority's communication to the population concerning the negative consequences of inactivity, still two thirds of the Norwegian adult population are insufficient physical active (Hansen et al., 2019; Helsedirektoratet, 2016).

Former research has established that lower levels of PA may be a contributing factor to mortality because of its influence on cardiorespiratory fitness (CRF) (Celis-Morales et al., 2017). CRF, usually expressed as maximal oxygen uptake ($VO_{2max}$), may be a mediating factor between PA and physical health (Ross et al., 2016). Due to $VO_{2max}$ being significantly trainable, a graded dose-response change in $VO_{2max}$ across levels of PA is observed (Bassett & Howley, 2000; Church, Earnest, Skinner & Blair, 2007; Lang et al., 2018; Ross et al., 2016).

However, $VO_{2max}$ is also influenced by individual factors such as age, gender, body composition and current training status, and is therefore not independently influenced by PA pattern (Joyner & Lundby, 2018; Lang et al., 2018; Mezzani, 2017; Skinner et al., 2001; Williams et al., 2017). Adults in Norway meeting the current PA recommendations of 150 minutes of moderate-to-vigorous PA (MVPA) weekly (WHO, 2010) are found to only have 5% to 13% greater $VO_{2max}$ compared with those that do not (Dyrstad, Anderssen, Edvardsen & Hansen, 2016). A wide range of low and high responders to guideline based PA program are also observed in the population (Joyner & Lundby, 2018; Skinner et al., 2001).

Fitness clubs provides a platform of a variety of activities, and is one of the main arenas for the general Norwegian adult population to conduct in PA (Thidermann & Rekdal, 2017; Virke, 2018). However, research on fitness club members are scant (Middelkamp & Steenbergen, 2015). To our knowledge, has none former studies investigated the association between PA level and $VO_{2max}$ in this specific population.

# 2. THEORY

## *2.1 Physical Activity*

PA is defined as: "*any bodily movement produced by skeletal muscles that requires energy expenditure"* (Caspersen, Powell & Christenson, 1985). PA can be performed in various domains, such as active transportation, as occupational PA, as leisure-time PA or as domestic activities (Howley, 2001). Leisure-time PA are activities performed during the individuals free time based on personal needs or interest (Strath et al., 2013).

The various PA domains can be classified as structured or incidental, and can considerably vary in intensity and duration (Caspersen et al., 1985; Howley, 2001; Strath et al., 2013). Leisure-time PA performed as exercise is characterized as structured, planned and frequent activity with the intention to improve or maintain physical health (Howley, 2001). While incidental PA is usually the result of daily activities either at work, as transportation or at home, where the intensity and duration is substantially lower (Howley, 2001; Strath et al., 2013).

PA is a complex behavior influenced by various of determinants, such as age, gender, ethnicity, social support, economic status, occupational status, community setting, physical fitness and several psychological factors (Choi, Lee, Lee, Kang & Choi, 2017; Wen, Herring, & Evenson, 2016; Lærum et al., 2008). Psychological factors include cognitive and emotional factors, such as perceived barriers, self-efficacy, as well as knowledge and attitude regarding PA and health (Choi et al., 2017).

### 2.1.1 Dimensions of physical activity

PA consists of five dimensions (Strath et al., 2013; WHO, 2010): *intensity*, refer to the metabolic demands of an activity (Strath et al., 2013). PA can be performed in light, moderate or vigorous intensity, which is equivalent to 1.5-2.9, 3.0-5.9 and >6.0 "Metabolic Equivalent of Tasks" (MET)-values, respectively (Howely, 2001; WHO, 2010). MET (1 MET=3.5 ml $O_2$/kg−1 /min−1) is a way of expressing energy expenditure from PA and is expressed in multiples of resting metabolic rate (Lee, Artero, Sui & Blair, 2010). *Frequency*, refers to how often PA is conducted within a specific time period (Howley, 2001; WHO, 2010). *Duration*, refers to the time spent in PA during a specific time period (Strath et al., 2013). Together, these three dimensions explain the total *volume* of PA (WHO, 2010).

Other dimensions of PA are activity type and context, whereas activity *type* refers to the physiological characteristics of the activity (Strath et al., 2013; WHO, 2010) (e.g. anaerobic, aerobic or strength), and the type of behavior (e.g. running, walking and cycling) (Strath et al., 2013; WHO, 2010). *Context* refers to in which setting the activity is performed (e.g. sports, fitness clubs, occupational or leisure-time) (Strath et al., 2013; WHO, 2010).

### 2.1.2 Global recommendations for Physical Activity

The Norwegian PA guidelines are in line with the global health recommendations proposed by The Worlds Health Organization (WHO) (Helsedirektoratet, 2016; WHO, 2010). The following recommendations use the dimensions of frequency, intensity, type and volume of PA needed for health enhancement and prevention of NCDs, and are based on a "dose-response" relationship between PA and health benefits (WHO, 2010). The current recommendations are therefore a minimum recommendation, and increased PA above these given recommendations provides additional health benefits (Helsedirektoratet, 2016; WHO, 2010).

The present PA recommendations for aerobic PA, proposed by the Norwegian health authorities for the adult population (18-64 years) are (Helsedirektoratet, 2016; WHO, 2010):

- ⇒ *"Participate in a minimum of 150 minutes of moderate intensity aerobic PA, or a minimum of 75 minutes of vigorous-intensity aerobic PA, or an equivalent combination of moderate-to-vigorous PA(MVPA) within a week"* (WHO, 2010).
- ⇒ *"For additional health benefits, adults should increase their moderate-intensity aerobic PA to 300 minutes per week"* (WHO, 2010).

The updated PA recommendations for adults has eliminated the requirement of aerobic PA to occur in bouts of at least 10 minutes (Piercy et al., 2018). The 2018 Advisory Committee concluded that bouts of any length may contribute to the health benefits associated with accumulated volume of PA.

## *2.2. Physical Fitness*

Physical fitness is a set of physical attributes, and refers to the state of physical and physiological characteristics that define the risk levels for premature development of diseases or morbid conditions (Caspersen et al., 1985). Being physically fit is seen as the "ability to carry out daily tasks without fatigue and with subsequent energy to enjoy leisure-time activity" (Caspersen et al., 1985).

The health-related fitness of an individual is expressed in five components (Vanhees et al., 2005): *a muscular component (e.g.* power, isometric, endurance and explosive strength) (Vanhees et al., 2005). *A cardiorespiratory component* (e.g. maximal aerobic power, lung and heart function) (Vanhees et al., 2005). A *morphological component* (e.g. body composition, abdominal visceral fat and bone density) (Vanhees et al., 2005). *A motor component* (e.g. balance, co-ordination and agility) (Vanhees et al., 2005). *A metabolic component* (e.g. glucose tolerance and insulin sensitivity) (Vanheees et al., 2005). Similar to activity level, an individual's physical fitness can differ from low to high, and each of the components of physical fitness can differ individually (Blair, Cheng & Holder, 2001).

### 2.2.1 Cardiorespiratory fitness

CRF, also referred to as *aerobic capacity,* is defined as: "the ability of cardiovascular and pulmonary systems to supply the oxygen demands of skeletal muscle during sustained PA" (Lee et al., 2010). CRF depends on a linked chain of processes such as (Ross et al., 2016); pulmonary ventilation and diffusion; the ability of muscle cells to receive and use nutrients and oxygen supplied by the blood; right and left ventricular function (both systole and diastole), and the ability of the vasculature to accommodate and efficiency transport blood from the heart to precisely match oxygen requirement (Ross et al., 2016).

Since CRF is directly related to the intergraded function of several physiological systems, it is considered to reflect total body health (Ross et al., 2016). There is also convincing evidence that moderate or high levels of CRF reduces the risk of numerous NCDs (Antunes-Correa, 2018; Lee et al., 2010; Myers et al., 2019; Ross et al., 2016), and prevents premature mortality in both gender regardless of other risk factors, such as increased age, smoking and obesity (Lee et al., 2010; Ross et al., 2016).

Mechanisms linking CRF to NCDs and mortality are caused by CRF's effect on improved insulin sensitivity, blood lipid profile, endothelial function and blood pressure (Lee et al., 2010; Ross et al., 2016), which may reduce the risk of diabetes type 2 and cardiovascular disease (Ross et al., 2016). Improved body composition, and reduced visceral adiposity (Ross et al., 2016), which may reduce the risk of metabolic syndrome (Myers et al., 2019; Ross et al., 2016). High levels of CRF may also reduce levels of inflammation and improves antioxidant systems (Lee et al., 2010; Mora, Cook, Buring, Ridker & Lee, 2007; Myers et al., 2019), which can reduce the risk of certain types of cancer, particularly colon and breast cancer (Ross et al., 2016).

### 2.2.2 Physical fitness in relation to physical activity and health

In epidemiological studies, both PA and physical fitness has been used independently and jointly as protective factors when assessing risk of disease as outcome (Swain, 2005). Therefore, the terms are often used interchangeably (Booth, Roberts & Laye, 2012; Myers et al., 2019). However, PA is a behavior, while physical fitness is an attribute (Myers et al., 2019). An essential distinction between PA and physical fitness is the intraindividual day-to-day variability of PA. Hence PA can vary on a daily basis, while physical fitness remains relatively static, or eventually change over time (Warren et al., 2010).

The majority of data regarding physical fitness and PA, has focused on CRF (Ross et al., 2016). A general statement is that increased PA improves CRF (Blair., 2001). Physical inactivity can also rapidly decrease CRF, which is particularly seen in bed rest studies (Booth et al., 2012). Yet, inactivity may not be the principal cause for low CRF (Williams, 2001). The amount of adaption in CRF from a standard PA dose is genetically and environmental determined and also influenced by current training status (Mann, Lamberts & Lambert, 2014). The majority of CRF health related benefits are seen when individuals move from the least fit category to the next least fit category (Lang et al., 2018). This suggest that the greatest benefits from CRF are gained when physically inactive individuals, become physically active (Lang et al., 2018).

### Reduction of noncommunicable diseases and premature mortality

Low levels of PA and CRF are associated with a reduction of cardiometabolic risk factors (O'Donovan, Hilsdon, Ukomunne & Stamatakis, 2013). Although, former research states CRF to be the dominant protective factor when assessing risk of cardiovascular disease (Blair et al., 2001; O'Donovan et al., 2013). "The Cooper Center Longitudinal Study" (previously The Aerobic Center Longitudinal study) began in 1970 as an observational epidemiological study who investigated health outcomes associated with PA and CRF (Lee et al., 2010; Stofan, DiPietro, Davis, Kohl & Blair, 1998). Men and women with the highest CRF had 47% and 70% lower risk of cardiovascular disease mortality, and 43% and 53% lower risk for all-cause mortality, respectively.

A meta-analysis conducted by Williams (2001) investigated PA and physical fitness as separate risk factors for cardiovascular and coronal heart disease. Both factors interpreted a reduction in relative risk for disease, yet the reduction was significantly greater for physical fitness (Williams, 2001). The greatest decrease in relative risk occurred between the lowest and second lowest fitness category, and a dose-response relationship between increased physical fitness and reduction in relative risk was observed. Swain (2005) also concluded that high values of CRF reduced the risk of cardiovascular disease greater than that obtained merely by being physically active.

However, there is uncertainty if this greater observed risk reduction is because physical fitness can be measured with greater accuracy, compared with PA (Blair et al., 2001). There is also substantiable evidence supporting the inverse relationship between PA and risk of NCDs (Shiroma & Lee, 2010). Reduction of inactivity itself is estimated to remove 6-10 % of the major NCDs (Lee et al., 2012). One study also found moderate and high amounts of PA to reduce the risk of coronary heart disease by 20-25% and 30-35%, respectively (Shiroma & Lee, 2010).

Furthermore, prior research has established that a clustering of risk factors is associated with higher risk of NCDs and all-cause mortality, compared with the risk obtain merely from a single risk factor (Lee et al., 2010). Therefore, a combination of inactivity and low physical fitness may be an even greater risk factor for NCDs. This was also investigated by "The Cooper Center Longitudinal Study" (Lee et al., 2010; Stofan et al., 1998). Activity level and fitness level were divided into three groups with correspondingly calculated all-cause death rates per 1000 person/year of observation (Blair et al., 1996; Blair, Cheng & Holder, 2001;Stofan et al., 1998). The highest death rates for both genders were in the unfit-inactive group, and the lowest death rates were in the high fit-highly active group (Blair et al., 2001), with a risk reduction of approximately 70% in mortality between the two groups.

## *2.3 Assessing physical activity level*

Various methods are available for the assessment of PA, and it can be assessed both with use of self-reports and with device measurements (Sylvia, Bernstein, Hubbard, Keating, Anderson 2014).

The most common self-reported PA measurement method is: *The International Physical Activity Questionnaire* (IPAQ) (Craig et al., 2003; Dyrstad, Hansen, Holme & Anderssen, 2014; Sylvia et al., 2014). Participants have to report time, duration and frequency of vigorous, moderate and light PA, and time spent sedentary the past 7 days (Dyrstad et al., 2014; Steene-Johannessen et al., 2016). There are two versions of the IPAQ, the short form, and the long form, and both can be administered by telephone interview or as self-administered. These are often more feasible and time beneficial to conduct than device-measured PA, and can be efficient when assessing PA context and type (Steene-Johannessen et al., 2016). However, self-reported PA relies on personal perceptions, memory, and judgments of the participant (Steene-Johannseen et al., 2016). Former research has therefore seen a tendency of overestimating PA with use of self-reports, which is mainly caused by recall- and social desirability bias, and interpretation of questions (Steene-Johannessen et al., 2016). It has also been seen to fail in capturing the lower end of PA spectrum, such as spontaneous light activity (e.g. household, transportation), due to recall bias (Steene-Johannessen et al., 2016; Sylvia et al., 2014). Thus, IPAQ are generally more reliable at the group level (Sylvia et al., 2014).

To capture an objective estimate of the different dimensions of PA, device measurements methods are increasingly used in studies involving PA patterns (Silfee et al., 2018). This measurement method captures PA through quantification of the activity movement and has the ability to measure a variety of metrics such as intensity, duration and bouts of the activity, as well as number of steps (Silfee et al., 2018). Indirect calorimetry and doubly labeled water are referred to as the criterion measurement techniques within device-measured PA

(Arvidsson, Fridolfsson & Börjesson, 2019). However, due to their expensive, wearable monitors, such as accelerometers, pedometers, wrist watch and heart rate monitors are commonly used in the public health setting (Silfee et al., 2018; Sylvia et al., 2014).

### 2.3.1 ActiGraph

Accelerometers are wearable devices that measure accelerations of the body segment to which the monitor is attached (Migueles et al., 2017). The device allows researchers to capture information about the frequency, intensity, and duration of PA over multiple days (Migueles et al., 2017; Silfee et al., 2018). Among available brands, the ActiGraph accelerometers account for more than 50% of published studies (Migueles et al., 2017). ActiGraph GT1M measures vertical acceleration in units called counts, which is a result of aggregating post-filtered raw accelerometer data usually over a specific time interval, called epochs (Kocherginsky, Huisingh-Scheetz, Dale, Lauderdale & Waite, 2017). Counts per minute (cpm) is the main variable expressed from the accelerometer, and the data can be stored in epochs range from 1 second to 60 seconds.

ActiGraph has been proven to be a valid measurement method for assessment of PA types such as running and walking (Hansen et al., 2014; Trost, Mclver & Pate, 2005; Warren et al., 2010). One study found a high correlation between cpm from walking and running measured with ActiGraph GT1M, and energy expenditure measured with indirect calorimetry (Hansen et al., 2014). However, since ActiGraph GT1M only measures vertical acceleration, it has some limitation in capturing activities such as cycling and resistance training (McCurdy, 2015; Warren et al., 2010). It also has limitations in measuring walking an incline or carrying heavy loads, since acceleration patterns remain unchanged under these conditions, despite the increased energy cost required (Warren et al., 2010). Since it is also not a waterproof device, this obviates its use in water sports (McCurdy, 2015).

#### Accelerometer placement, cut-points and measurement duration

The instrument can be placed on several body parts such as wrist, thigh and hip, depending on the movement intended to measure (Arvidsson et al., 2019). Predominantly of research, has used a standardized placement of the accelerometer near the non-dominant hip (McCurdy, 2015; Migueles et al., 2017). Hip placement has been suggested as optimal to measure whole body movement, since it is a location close to the center of the body, and is seen to provide more accurate measure of overall activity level compared with wrist and thigh placement (Arvidsson et al., 2019; Mathie, Coster, Lovell & Celler, 2004).

Intensity is usually expressed as cut-points, which in turn are count thresholds corresponding to the energy cost of the given intensity to the data set (Migueles et al., 2017). These are defined to distinguish between light, moderate and vigorous PA, as well as sedentary time. There is a broad range of different cut-points used to distinguish between PA intensities in former research (Migueles et al., 2017). Application of different cut-points can result in major differences in estimating prevalence of intensity-specific activity level, particularly cut-points to determine moderate PA (Pedišić & Bauman, 2015). However, choice of cut-points are usually determined by the studied population and placement of the accelerometer (Migueles et al., 2017). The value of <100 cpm for sedentary behavior is most common, and was used in the "National Health and Nutrition Examination Survey", as well as other surveillance (Kim, Lee, Peters, Gaesser & Welk, 2014). One study investigated average of published cut-points for adults in accelerometer studies (Metzger et al., 2008). These were 2020 cpm for MVPA and >5999 for vigorous PA (Metzger et al., 2008). Hansen et al (2019) also used these following cut-points for their Norwegian adult sample: sedentary behavior categorized as <100cpm, light intensity categorized as 100-1999 cpm (1.6-2.9 METs) and MVPA categorized as >2020 cpm (≥3 METs) (Hansen et al., 2019).

A minimum of 3 to 5 days of measuring is considered appropriate in order to obtain estimates of PA behavior (Aadland & Ylvisåker, 2015; Trost et al., 2005). However, seven days of measuring is preferred, preferably including both weekdays and weekend days, due to day-to-day variability of PA (Warren et al., 2010). Ten hours of measuring time have been recommended as a criterion for one valid measuring day (Migueles et al., 2017).

## *2.4 Accessing cardiorespiratory fitness*

### 2.4.1 Maximal oxygen uptake

CRF is usually measured as $VO_{2max}$, which is defined as: "*the highest rate at which oxygen can be taken up and utilized by the body during severe exercise*" (Bassett and Howley, 2000; Williams et al., 2017). Thus, it represents the maximal integrated physiological capacity of the cardiovascular, respiratory and skeletal muscle systems, entitled the maximal aerobic capacity (Antunes-Correa, 2018). $VO_{2max}$ is limited by several physiological factor, which may be divided into central and peripheral factors (Antunes-Correa, 2018; Bassett & Howley, 2000). Central factors contain of the maximal cardiac output, oxygen carrying capacity of the blood and the pulmonary diffusing capacity (Bassett & Howley, 2000). While peripheral factors contain of characteristics of the skeletal muscles. However, altering of these physiological factors are to some extent limited (Bassett & Howley, 2000). In large groups of healthy human, total body hemoglobin mass and maximal cardiac output seem to be the predominate determinate of $VO_{2max}$ (Joyner & Lundby, 2018). Improvements in $VO_{2max}$ from PA is primarily a consequence of increased maximal cardiac output, such as stroke volume (Bassett & Howley, 2000).

$VO_{2max}$ is usually expressed as absolute $VO_2$, unites of liters (L/min) or relative $VO_2$ to the individuals body weight (mL·kg$^{-1}$·min$^{-1}$) (Kaminsky, Arena & Myers, 2015). Absolute $VO_{2max}$ reflect the absolute total amount of oxygen consumed, regardless of size, age or gender. However, since two individuals of different size may have the same absolute $VO_{2max}$ value, $VO_{2max}$ is usually expressed as relative $VO_{2max}$ (Ranković et al., 2010).

## Demographical influence on maximal oxygen uptake

Age, gender, body composition, PA habits and genetics account for the greatest influence on relative $VO_{2max}$ (Mezzani, 2017; Whaley, Kamisky, Dwyer & Getchell, 1995). $VO_{2max}$ normally peaks between the age of 20-30 years, and starts to decline with increasing age (Bassett & Howley, 2000; Betik & Hepple, 2008). There is also a clear gender difference in $VO_{2max}$ (Bassett and Howley, 2000; Joyner & Lundby, 2018; Mezzani, 2017; Williams et al., 2017). Women have in general around 7 mL·kg$^{-1}$·min$^{-1}$ lower $VO_{2max}$ than men (Lee et al., 2010). This is mainly caused by smaller stroke and blood volume, lower hemoglobin level and less muscle mass in comparison with men (Mezzani, 2017).

There are also well known inter-individual differences in adaption from a particular training dose on $VO_{2max}$ (Bassett, & Howley 2000; Joyner & Lundby, 2018; Williams et al., 2017). Some studies has documented that as much as 10% of individuals achieve poor or no improvement in $VO_{2max}$ after endurance training (Hautala et al., 2006). For the young and middle-aged population, genetic and former training status seems to be the main influence on $VO_{2max}$ trainability (Joyner & Lundby, 2018). The genetic influence on $VO_{2max}$ is estimated to be approximately 50%, while several genes have also been identified as possible predictors of $VO_{2max}$ trainability (Williams, et al., 2017). These are often divided into low and high responders to a particular training dose (Joyner & Lundby, 2018), whereas high responders show greater response to a particular training dose, compared with low responders.

### 2.4.2 Cardiopulmonary exercise test

$VO_{2max}$ is usually assessed with a Cardiopulmonary exercise test (CPET), which is performed under laboratory conditions using an incremental exercise protocol and technological advanced gas analysis devices (Lee et al., 2010; Schoffelen, Hoed, Breda & Plasqui, 2019). With a graded exercise test, we can observe the dynamic relationship between exercise workload and physiological response within the metabolic, musculoskeletal, cardiovascular and pulmonary system (Beltz et al., 2016). The test requires a linear increase in exercise intensity over time until the individual is unable to maintain or tolerate the given workload (Beltz et al., 2016).
CPETs are commonly assessed on a treadmill or cycle protocol (Aadland et al., 2017; Lee et al., 2010). For most participants, walking and running are preferred due to familiarity with upright locomotion, and it involves greater muscle mass utilization and greater work against gravity, in comparison with cycling protocols (Albouaini et al., 2007; Beltz et al., 2016).

One example of a graded treadmill protocol that is frequently used in the public health setting is the stepwise modified Balke protocol, which is a walking test that require maximal exhaustion of the participant (Balke & Ware, 1959). The participant usually starts at an initial walking speed of 4.5 km/h with an increase in treadmill elevation every minute up until 20% (Balke & Ware 1959). Thus, this protocol is seen to provide more modest increase in workload, in comparison with other graded treadmill tests (Flecther et al., 2013). This is particularly useful for some population groups, for instance elderly (Fletcher et al., 2013).

The Balke protocol is also well suited in the clinical setting, since it does not require running, and the initial stages is of low intensity (Aadland et al., 2017). This protocol was for instance assessed in the Norwegian mapping of physical fitness among adults and elderly (2009-2010) (Anderssen et al., 2010). Furthermore, findings from one of the most influential cohort studies "The Cooper Center Longitudinal Study", rely on time to exhaustion measured with the Balke protocol (Aadland et al., 2017; Blair et al., 1996; Stofan et al., 1998).

**End criteria's for assessing maximal oxygen uptake**

In order to increase the reliability and validity of the CPET, a combination of standardized criteria's must be meet during the test (Beltz et al., 2016). One of them is the presence of oxygen utilization "plateau", which is recognized by that oxygen utilization starts to even out, while the increase in workload is constant (Beltz et al., 2016). Although, this criterion is not always assessable in a practical setting (Edvardsen, Hem & Anderssen, 2014). In some cases, as intensity increases, the individual reaches volitional fatigue before plateau occurs (Kenney, Wilmore and Costill, 2009, p. 122). The Balke protocol is also a protocol that does not achieve a "steady state". Therefore, a large variety of end criteria's can be assessed. For instance, the participants rating of perceived exertion (Borg scale 6-20), the respiratory exchange rate (RER), the percentage of the age-adjusted estimate of maximal heart rate, or a combination of the mentioned criteria's (Borg, 1970; Edvardsen et al., 2014;Kenney et al., 2009, p.117).

RER is the ratio of carbon dioxide production and oxygen consumption, and can be used as an indirect measure of lactic acid accumulation, and is also a method to reflect the intensity of the CPET (Edvardsen et al., 2014; Kenney et al., 2009,p. 118; Mezzani, 2017). A higher RER reflects a higher contributing of carbohydrates energy production, and a lower RER reflects a higher contribution of fat (Kenney et al., 2009, p. 265).

## 2.4.3 Reference values of maximal oxygen uptake

Reference values for $VO_{2max}$ are required to interpret the results of CPETs, and to determine if the participant is below or above given normative values specific for age and gender (Aspenes et al., 2011; Edvardsen et al., 2013). There are two studies in Norway that have developed normative reference values for $VO_{2max}$ (Aspenes et al., 2011; Edvardsen, Hansen, Holme, Dyrstad & Anderssen, 2013). One study was conducted by The Norwegian University of Science and Technology in Trondheim, Norway (Aspenes et al., 2011).

However, since Edvardsen et al (2013) study was conducted by The Norwegian School of Sport and Sciences in Oslo, Norway, was these used as reference values in this present study (Edvardsen et al., 2013). The sample contained of 759 healthy participants drawn from the general population in Norway, within the age range of 20-85 years. $VO_{2max}$ was accepted if the RER score was ≥1.10, and a Borg score of ≥17. The mean RER was 1.22 in the 20- to 49-year-old participants and decreased to 1.13 in the oldest age group (Edvardsen et al., 2013).

Table 1 presents reference values for $VO_{2max}$ and corresponding maximal heart rate, perceived exertion (Borg scale) and RER value for men within following age groups: 20-29, 30-39, 40-49, 50-59, 60-69 and 70-85 (Edvardsen et al., 2013).

***Table 1:****Results are presented as mean (and standard deviation, SD) Reference values for $VO_{2max}$ and corresponding maximal heart rate, Borg scale and RER for men within the age groups: 20-29, 30-39, 40-49, 50-59, 60-69 and 70-85 (Edvardsen et al., 2013).*

| **Age** (yrs) | **$VO_{2max}$** ($ml/kg^{-1}/min^{1}$) | **RER** ($VCO_2/V_0$) | **$HR_{max}$** *(beats/min)* | **Borg-scale** *(1-20)* |
|---|---|---|---|---|
| **20-29** *n=38* | 48.6 (±9.6) | 1.23 (±.09) | 193.4 (± 21.4) | 17.8 (±1.5) |
| **30-39** *n=73* | 46.2 (±8.5) | 1.24 (±.10) | 189.4 (± 8.8) | 17.9 (±1.1) |
| **40-49** *n=91* | 42.7 (±9.3) | 1.22 (±.10) | 182.3 (±12.1) | 17.7 (±1.2) |
| **50-59** *n=88* | 36.8 (±6.6) | 1.19 (±.12) | 170.2 (±15.3) | 17.5 (±1.3) |
| **60-69** *n=81* | 32.4 (±6.4) | 1.16 (±.10) | 163.0 (±14.2) | 17.3 (±1.4) |
| **70-85** *n=23* | 30.1 (±4.8) | 1.12 (±.08) | 151.7 (±13.1) | 17.8 (±1.1) |

$HR_{max}$= Maximal heart rate. $VO_{2max}$= Maximal oxygen uptake. RER = Respiratory exchange rate.

Table 2 presents reference values for $VO_{2max}$ and corresponding maximal heart rate, perceived exertion and RER value for women within following age groups: 20-29, 30-39, 40-49, 50-59, 60-69 and 70-85 (Edvardsen et al., 2013).

***Table 2**: Results are presented as mean (and standard deviation, SD) Reference values for $VO_{2max}$ and corresponding maximal heart rate, Borg-scale and RER-score for women within the age groups: 20-29,30-39,40-49,50-59,60-60 and 70-85 (Edvardsen et al., 2013).*

| **Age** (yrs) | **$VO_{2max}$** ($ml/kg^{-1}/min^{1}$) | **RER** *($VCO_2/V_0$)* | **$HR_{max}$** *(beats/min)* | **Borg-scale** *(1-20)* |
|---|---|---|---|---|
| **20-29** *n=37* | 40.3 (±7.1) | 1.22 (±.10) | 189.5 (±7.1) | 17.9 (±1.8) |
| **30-39** *n=63* | 37.6 (±7.5) | 1.22 (±.10) | 184.7 (± 8.2) | 17.8 (±1.4) |
| **40-49** *n=86* | 33.0 (± 6.4) | 1.20 (±.10) | 179.6 (±10.1) | 17.3 (±1.5) |
| **50-59** *n=79* | 30.4 (± 5.1) | 1.18 (±.10) | 172.8 (± 9.8) | 17.4 (±1.3) |
| **60-69** *n=59* | 28.7 (± 6.6) | 1.18 (±.12) | 165.9 (±12.0) | 17.6 (±1.0) |
| **70-85** *n=41* | 23.5 (±4.1) | 1.13 (±.12) | 156.8 (±14.3) | 17.5 (±1.0) |

$HR_{max}$= Maximal heart rate. $VO_{2max}$= Maximal oxygen uptake. RER = Respiratory exchange rate.

## *2.5 Association between total activity level and maximal oxygen uptake*

It is well documented that structured exercise training, can improve $VO_{2max}$ over time (Joyner & Lundby, 2018). However, there are also adaptive responses to PA performed incidental, which may improve $VO_{2max}$, even though this was not the main motive for conducting in the activity (Joyner & Lundby, 2018; McGuire & Ross, 2011).

CRF is suggested to provide a reflection of more recent activity level at the group level (Lang et al., 2018). Although, there is a growing body of evidence confirming the heterogeneity of the association between PA and $VO_{2max}$ (Ross et al., 2015). The "inter-individual" differences in response to PA may also interpret some discrepancy concerning this association (Joyner & Lundby, 2018). Hence, a substantive proportion of participants in previous research, has been classified as non-responders on $VO_{2max}$ (Bouchard & Rankien, 2001; Hautala et al., 2006).

### 2.5.1 Self-reported physical activity and maximal oxygen uptake

Since self-reported PA is a feasible and cost-efficient measurement method, the majority of previous research within this field has relied on self-reported PA (Aadahl et al., 2007; Berthouze et al., 1995; Matthews, Heil, Freedson & Pastides, 1999; Nes et al., 2011; Papathanasiou et al., 2010; Schembre & Riebe, 2011; Siconolfi et al., 1985). Although, self-reported PA, such as IPAQ, is not specifically designed to assess $VO_{2max}$, they do report frequency, intensity and duration of the individuals recently PA habits, which is related to $VO_{2max}$ (Schembre & Riebe, 2011).

### Non-exercise models

When investigating the association between self-reported PA and $VO_{2max}$, several "non-exercise models" of CRF have been developed with the aim to predict $VO_{2max}$ in the measured population (Matthews et al., 1999; Nes et al., 2011; Neto & Farinatti, 2003; Papathanasiou et al., 2010; Schembre & Riebe, 2011). CPETs of $VO_{2max}$ are usually replaced with a multiple linear regression model (Neto & Farinatti, 2003). These models often include easily accessible measures such as self-reported PA, gender, body composition and age (Nes et al., 2011; Neto & Faninatti, 2003). Additionally, one study observed that the predictive power of the non-exercise model was higher if it accounted for the intensity of PA, rather than if the participant had performed PA or not (Siconolfi et al., 1985). Thus, PA intensity correspondingly became a vital factor in prediction studies on $VO_{2max}$ (Neto & Farinatti, 2003; Silconolfi et al., 1985).

Schembre & Riebe (2011) observed that, when adjusting for covariates, self-reported vigorous PA and gender was significantly associated with $VO_{2max}$. Similarly, Papathanasiou et al (2010) found vigorous PA to be significantly associated with $VO_{2max}$. Yet, moderate PA showed no significant association with $VO_{2max}$ (Papathanasiou et al., 2010). However, both these study samples are limited to university students within the age group of 18 to 29 years (Papathanasiou et al., 2010; Schembre & Riebe, 2011). Thus, this limit generalization to other age groups. Another study found self-reported vigorous PA, in addition to gender, age and body weight, to account for 69% of variance in measured $VO_{2max}$ (Aadahl et al., 2007). Yet, total amount of PA was not significantly associated with $VO_{2max}$. Comparably, Nes et al (2011) observed that self-reported PA, age and waist circumference to account for 59% and 54% of variance in $VO_{2max}$ for men and women, respectively.

Since former research has seen a trend of overestimating activity level with use of self-report (Steene-Johansen et al., 2016), these referenced studies (Aadahl et al., 2016; Matthews et al., 1999; Nes et al., 2011.; Papathanasiou et al., 2010; Schembre & Riebe, 2011) are subject to major misclassification of activity level. Non-exercise models also tend to overestimate $VO_{2max}$ in unfit individuals, and underestimate $VO_{2max}$ in fit individuals (Jackson et al., 1990; Mathews et al., 1999; Scembre & Riebe, 2011). One study found their non-exercise model to underestimate the true $VO_{2max}$ among participants with >55. $mL \cdot kg^{-1} \cdot min^{-1}$ (Jackson et al., 1990). Another study concluded that non-exercise models fails to provide the accuracy needed for categorizing CRF within large epidemiological cohort studies where the purpose is to assess mortality risk (Whaley et al., 1995).

## 2.5.2 Device-measured physical activity and maximal oxygen uptake

Some studies with device-measured PA, has also been conducted within this field. Activity level is usually assessed with an accelerometer or a fitness watch (Cao et al., 2010; Dyrstad et al., 2016; Kwon et al., 2019; Mundwiler et al., 2017; Prioreschi et al., 2017).
When adjusting for potential covariates, one study found a significant association between leisure-time PA and $VO_{2max}$ (Mundwiler et al., 2017). Participants who conducted in sufficient MVPA during work days also had a significant higher $VO_{2max}$ than participants who did not (Mundwiler et al., 2017). Similarly, another study found a significant association between energy expenditure from PA measured with a watch fitness watch (Fitbit) and $VO_{2max}$ (Kwon et al., 2019). Yet, there is lack on validity studies on activity level measured with a fitness watch (Kwon et al., 2019). Furthermore, both these findings (Kwon et al., 2019; Mundwiler et al., 2017) rely on an accelerometer placed on the wrist.

In contrast, another study measured activity level with an accelerometer placed on the hip for seven constructive days (Prioreschi, Brage, Wesgate, Norris & Micklesfield, 2017). When adjusting for covariates, the study found a significant positive association between minutes in MVPA, in addition to lower BMI and male gender, with $VO_{2max}$. However, a limitation with these three declared studies (Kwon et al., 2019; Mundwiler et al., 2017; Prioreschi et al., 2017) is that they rely on a cross-sectional study design, which may limit any causality conclusions.

One study found daily steps per day, minutes in MVPA and vigorous PA was significantly associated with higher $VO_{2max}$ among men and women (Cao, Myatake, Higuchi, Miyachi & Tabata., 2010. The study concluded that step counts and vigorous PA was useful when predicting $VO_{2max}$ variance in men, and MVPA and vigorous PA was useful when prediction $VO_{2max}$ variance in women. Similar findings was found by Dyrstad and colleagues (2016). The study assessed activity level both with use of self-reported PA (IPAQ) and device-measured PA (Actigraph). The study found a significant association between device-measured vigorous PA and $VO_{2max}$ for men and women, and a significant higher $VO_{2max}$ was observed for participants who were sufficient active (>150 minutes of MVPA) (WHO,2010) during a week (Dyrstad et al., 2016). Yet, the study observed that variation in measured activity level may reflected a generally small variation in $VO_{2max}$ (Dyrstad et al., 2016). The difference in $VO_{2max}$ between the most physical active and least active group was only 16%. Thus, this may indicate that $VO_{2max}$ is more dependent on other factors than the individual's activity level. However, this study also had some limitations (Dyrstad et al., 2016). $VO_{2max}$ was measured 5-8 months after self-reported and device-measured activity level. The participants may therefore have increased or decreased their $VO_{2max}$ after their respected activity level was measured (Dyrstad et al., 2016).

### 2.5.3 Physical activity intensity effect on maximal oxygen uptake

In epidemiological studies who control for energy expenditure, the greatest health benefits are seen at higher intensities (Swain & Franklin, 2006; Ross et al., 2015). The majority of evidence favors more cardioprotective benefits from vigorous intensity PA than from moderate intensity PA. Therefore, there should be a greater association between vigorous intensity PA and higher $VO_{2max}$ (Swain, 2005). This greater association is particularly observed in self-reported studies (Aadahl et al., 2007; Papathanasiou et al., 2010; Schembre & Riebe, 2011). However, this may be because vigorous PA is easier recalled and reported in questionnaires (Aadahl et al., 2007). Dyrstad et al (2016) also found self-reported vigorous PA to overestimate device-measured vigorous PA with 9 and 17 minutes for men and women, respectively.

Yet, the favors of vigorous PA, may not be the case for untrained participants. Current training status may have an influence on the association between intensity specific PA and $VO_{2max}$ (Lang et al., 2018). The higher the initial state of fitness, the smaller is the relative improvement for the same volume of training is observed (Kenney et al., 2009, p.268). Trained participants usually demand higher intensities (>85% of maximal heart rate), longer durations and more frequent bouts of PA, to improve $VO_{2max}$ (Lang et al., 2018).

However, this does not seem to be the case for untrained participants. Swain and Franklin (2002) concluded that no threshold intensity was appearance for participants with $VO_{2max} < 40$ $mL \cdot kg^{-1} \cdot min^{-1}$. Usually a significant increase in $VO_{2max}$ was observed, regardless of training intensity (Swain & Franklin, 2002).

Another study investigated if there was a difference effect on $VO_{2max}$ by either 150 minutes of moderate PA or 75 minutes of vigorous PA weekly among overweight and untrained participants (Jung, Locke, Bourne, Beauchamp & Lee., 2020). Both groups increased their $VO_{2max}$, and no significant group differences on $VO_{2max}$ was observed (Jung et al., 2020). It is also stated that brisk walking (<50% of maximal heart rate) 3 to 4 times a week, over a period of >12 weeks, can obtain an increase of 5-15% in $VO_{2max}$ among untrained participants (Lang et al., 2018).

## *2.6 The Fitness club industry*

The Fitness Club industry has since the 1990s, grown to be one of the most important arenas for the general population to engage in PA. In 2018, it was estimated to be a total of 210 number of fitness clubs, with approximately 183 million members worldwide (IHRSA, 2018). Number of fitness clubs has also increased extensively in Norway during the last decade. In 2008 it was estimated that there was a total of 477 fitness clubs in Norway (Virke, 2018). This increased to a total of 1179 per October 2018, with 141 clubs in Oslo only (Virke, 2018). A third of the physical active population in Norway reports fitness clubs as their most used setting for exercise (Thidermann & Rekdal, 2017).

Considering the enormous health benefits of PA, it is apparent that the fitness club industry, contributes to an enhancement of public health. In the Public Health Report (2014-2015), The Norwegian Government stated that the fitness club industry provides a major contribution to public health by facilitating and promoting PA (Thidemann, Tønnessen, Pettersen, & Arntzen, 2016). Two thirds of the people surveyed in Norway also reports low levels to no PA before signing up at a fitness club (Thidermann & Rekdal, 2017).

Fitness clubs are found to be preferred due to the comfort of the facilities and the possibility to commit to specific exercise times and activities, while also providing an opportunity for social interactions, achieve desired health benefits and improve one’s physical appearance (Riseth et al., 2019). One study found that the majority of new fitness club members reported they were motivated to exercise by health-related reasons (MacIntrosh & Law, 2015). Particularly improving their own well-being, in the form of improved physical fitness, mental health and appearance (MacIntrosh & Law, 2015). This was also found in a study by Gjestvang, Stensrud & Haakstad (2019). The study reported a moderate improvement in

$VO_{2max}$, but no changes in maximal muscle strength and body composition during the first year of a fitness club membership. These were the results despite an increase in physical fitness as the main motive for exercise among the participants (Gjestvang et al., 2019).

“The Sapporo fitness club trial” also found that regular exercise at a fitness club was associated with an increase in $VO_{2max}$ (Nishijima et al., 2007). The study investigated the effect on cardiovascular risk associated with training in a fitness club over 6 months (Nishijima et al., 2007). The intervention group, who trained on average, 2.6 times per week at their respected fitness club, had a significant greater improvement in $VO_{2max}$ (2.0 $mL \cdot kg^{-1} \cdot min^{-1}$) compared with the control group. Another study also found fitness club members to have more favorable cardiovascular outcomes compared to non-members (Schroeder, Welk, Franke & Lee, 2017).

# 3. Aim of the study

With respect to the development of the evidence-based PA recommendations (WHO, 2010), it is expected that individuals who are sufficiently active, also have higher levels of $VO_{2max}$. Hence, it can be argued that physical fitness is a mediating factor that affects the strength of association between PA level and development of disease (Celis-Morales et al., 2017; Ross et al., 2016). Thus, it is essential to investigate if individuals with high activity level, has higher levels of $VO_{2max}$, compared with those with low activity levels.

Assessment of $VO_{2max}$ requires skilled technicians, expensive equipment, are time consuming, as well as the potential risk to maximal physical efforts for the participant. Such testing may be unpractical to implement in the general adult population (Dyrstad et al., 2016; Nes et al., 2011). An important contribution to future research would therefore be if $VO_{2max}$ could be predicted by a non-exercise model. For instance, by a non-exercise model who included device-measured PA and individual factors that are known to have a vital influence on $VO_{2max}$.

The majority of previous research within this field, with respect to the association between PA level and $VO_{2max}$, as well as non-exercise models, has used self-reported PA (Aadahl et al., 2007; Nes et al., 2011; Papathanasiou et al., 2010; Schembre & Riebe, 2011; Siconolfi et al., 1985). Numerous of former findings are also not updated (Aadahl et al., 2007; Berthouze et al., 1995; Cao et al., 2010; Silconolfi et al., 1985). Thus, since the current PA recommendations was recently updated, has former device-measured studies only included PA who was performed in bouts of at least 10 minutes in their analysis (Dyrstad et al., 2016; Mundwilder et al., 2017).

The associations between PA and $VO_{2max}$, as well as the accuracy of a non-exercise model still need to be clarified with further investigation. Device-measured PA may contribute to a greater methodological accuracy, and eliminate potential bias due to overestimation of PA level when use of self-reports. With use of a longitudinal study design, we are able to investigate the association between total activity level and $VO_{2max}$ at two different occasions, and if changes in the predictive variables (minutes in MVPA and total cpm) over time, reflects changes in the outcome ($VO_{2max}$). With regards to the updated PA recommendations, that does no longer include bouts of 10 minutes, it would also be valuable to investigate if PA performed in any bouts was associated with higher levels of $VO_{2max}$.

The majority of former research has also investigated this in the general population. To our knowledge, has no other studies investigated this in a fitness club setting. Since $VO_{2max}$ was the only factor associated with exercise attendance among fitness club members (Gjestvang et al., 2019), it may be valuable to investigate if there is an association between total activity level and $VO_{2max}$ in this particular setting as well.

Following research aim was developed:

*"The aims of the present study were to investigate the association between device-measured PA (MVPA and total cpm) and results of a* $VO_{2max}$ *test among untrained adults at start-up and following 1-year of fitness club membership. Further, we wanted to investigate if a non-exercise model including device-measured PA and individual factors (fat mass%, BMI, age and gender) could predict* $VO_{2max}$*"*

# 4. METHOD

## *4.1 Study design*

This master thesis was part of the research project: “Fitness clubs – a venue for public health?”. A longitudinal prospective study that followed new members at 25 fitness clubs in Oslo, Norway to study different factors that may explain why someone manage while others fail to maintain exercise over time. The research project was financed and conducted by the Norwegian School of Sport Sciences within the period of October 2015 to October 2017.

The overall research project, including test protocol and test procedure was reviewed by the Regional Committee for Medical and Health Research Ethics (REK 2015/1443 A) who concluded that, according to the “Act on medical and health research” (the Health Research Act 2008), the research project did not require full review by REK (Appendix 1). The project was approved by the Norwegian Social Science Data Service (NSD 44135) (Appendix 2 and 3).

In accordance with the Declaration of Helsinki, before participating, all participants received written information about the project’s purpose and procedures. Participation involved no harmful or invasive examinations. Discomfort due to maximal effort was seen as harmless among healthy adults. The participants provided informed consent to conduct in the project, and were in position to withdraw from the project at any time with no justification required. All data from the project was anonymized and kept confidential according to the Health Research Act. No economic compensation was given.

### 4.1.1 Participants

Eligibility criteria were: ≥18 years, less than 4 weeks fitness club membership, untrained defined as exercising less than 60 minutes a week at moderate or vigorous intensity, or brisk walking less than 150 minutes a week the previous 6 months.

All new members were approached to take part in the study. After registration at their respective fitness club, they received an email regarding information about the research project (Appendix 4). Figure 1 illustrates how many newly registered members who contacted the research group concerning interest in the project, and how many participants were measured at membership start-up and at 1-year follow-up.

A total of 125 participants underwent device-measured PA, measures of $VO_{2max}$, body composition and anthropometry, as well as answering an electronic questionnaire at membership start-up. Of these, were 61 participants measured again at 1-year follow-up. A total of 64 participants were lost to follow-up, whereas 16 due to life situation, 10 due to disease, and 38 due to other reasons.

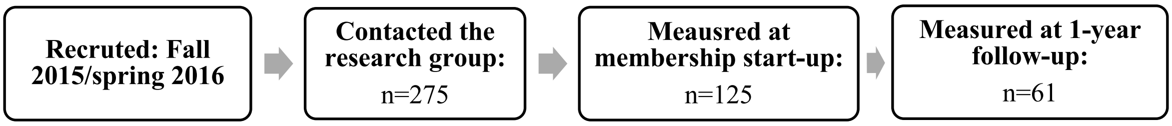

***Figure 1:*** *Flowchart diagram of total participants who contacted the research group, and total participants measured at membership start-up and at 1-year follow-up.*

## *4.2 Data collection and measurements*

### 4.2.1 Electronic questionnaire

The original electronic questionnaire took approximately 30 minutes to complete, and contained of 52 questions at membership start-up, and 65 questions at 1-year follow-up. Six questions concerning descriptive characteristics of the participants were included in this master thesis. These are translated and presented below:

1. Gender:

Options: *"male", "female"*

2. Age:

Options: *years*

3. What was your household's gross income (in NOK) the preceding year? (include all income from work, social security, social welfare and etc.)

Options: *"<125.500", "125.000-200.00", "201.000-300.00", 301.000-400.000", "401.000-550.000", "551.000-7000.00", "701.000-850-000", ">850.000".*

4. What is your current occupation?

Options: *"employed in the public sector", "employed in the private sector", "self-employed, "apprentice/vocational practice", "disability benefit", "seeking employment/furloughed", "homemaker", "student", "retired", "other", "choose not to answer".*

5. Educational attainment (*Norwegian education system):

Options: “*standard level of education”, “higher education (vocational)”, “higher education (academic)”, “further education” (less than 4 years),” further education” (more than 4 years), other form for education, “choose not to answer”*

6. <u>Do you smoke daily?</u>

Options: “y*es”, “no”.*

### 4.2.2 Measures of total physical activity level

Total PA (total cpm) and minutes in MVPA were assessed with preprogrammed accelerometers “ActiGraph GT1M” at membership start-up and after 1-year follow-up. The participants were given standardized instructions, including how to wear the accelerometer prior to the intervention periods. The accelerometers were worn on the hip, for seven constructive days. All participants accumulating in a minimum of 10 hours of activity recordings each day for at least 4 days were included in the data analysis.

Different intensities of PA with count threshold corresponding to the energy cost of the given intensity were applied in the analysis. Sedentary behavior was defined as all activity <100 cpm. Light intensity PA was defined as all activity between 100-2019 cpm, and MVPA was defined as all activity ≥2020 cpm. To define proportions meeting PA recommendations, the total amount of minutes above 2020 cpm during the measuring period was summed up, then the number was then divided on amount of days with valid registration. Fulfilling of PA recommendations was determined if the participant accumulating in a minimum of 150 minutes of weekly MVPA (WHO, 2010).

PA data are presented as 1) total activity level (cpm), 2) number of minutes spent in MVPA, 3) percentage of the participants accumulating in ≥150 minutes of MVPA weekly.

### 4.2.3 Measures of maximal oxygen uptake

CRF was measured as $VO_{2max}$ with a CPET at membership start-up and at 1-year follow-up. Body weight was measured prior to the test protocol for accurate measures. The CPET was conducted on a treadmill, using the stepwise modified Balke protocol until exhaustion. $VO_{2max}$ was measured with indirect calorimetry (Oxycon Pro; Jaeger). The participants breathed through a Hans Rudolph mask, which covered the mouth, and was nose-attached to a non-rebreathing tube. Expired air/gas were continuously sampled each 30 second during the CPET. To measure the participants maximal heart rate, a heart rate monitor (Polar RS800) was used. The participant started with a 3 min warm-up at an initial speed of 4.5 km/h with no inclination. Further, the inclination increased by 5% every minute up to 20%. The speed was kept constant at 4,5 km/h. Accordingly, the speed increased 0.5 km/h every minute, while inclination was kept constant at 20%.

The Borg Scale (range 6-20) was used for rating of perceived exertion. The CPET was stopped when the participants reach maximal exhaustion (≥ 19 on the Borg scale).
To verify a valid (maximal) $VO_{2max}$, RER had to be between, 1.10 and 1.30, according to the age-dependent results reported by Edvardsen and colleagues (2013). The highest $VO_{2max}$, and the highest RER corresponding to the highest minute ventilation were reported.
All analyzers were calibrated after manufactures guidelines prior to each test day, and all CPET were supervised by the same research fellow to obtain inter-rater reliability.

### 4.2.4 Anthropometry and body composition

Measures of height, body weight and body composition were conducted under standardized test procedures, without shoes and light clothing. The participants fasted a minimum two hours before measures. Height was measured with a stadiometer (Seca scale, Mod: 8777021094, S/N: 5877248124885). Body weight and body composition (fat mass%) were measured with Inbody 720 (Biospace). To compresence for clothing, the measurement tool was calibrated to subtract 0.5 kg. The participant had to stand straight, with their feet aligned with the electrodes on the measuring platform, with the handles in each hand. Research fellows plotted in ID number, height and gender prior to the measures. The test took approximately 2 minutes to complete.

Participants with a BMI >25 was classified as overweight, and participants with a BMI >30 was classified with obesity (WHO, 2020). Reference values for fat mass% was 30% for women and 20% for men.

## 4.3 Statistical analysis

Data were analyzed using *SPSS Statistical Software V.24.0 for Windows.* Level of significance was set as $p \leq 0.05$ for all analyzes.
Before univariate analysis was performed, the data material was tested for normality by use of Kolmogorov-Smirnov test. For normal distributed data, an independent t-test were assessed to address gender differences between continuous variables. Non-parametric test was performed for non-normal distributed data, and a chi-square test was performed on categorical variables. Background variables are presented as means with standard deviation (SD) for continuous data and frequencies (n) and percentages (%) for categorical variables.

To assess the associations between device-measured PA (MVPA and total cpm) and results on the $VO_{2max}$ test, we included data obtained at membership start-up and after 1-year of fitness club membership. To interpret potential independent covariates, univariate analysis was performed on participants above or below reference values for $VO_{2max}$ (Edvardsen et al., 2013). If there was also pre-existing evidence that a factor could be a potential covariate for the association between device-measured PA and $VO_{2max}$, the factors were included in the analysis.

A Pearson correlation was performed for minutes in MVPA and $VO_{2max}$, as well as total cpm and $VO_{2max}$ at membership start-up and at follow-up. To assess for potential covariates, and to develop a non-exercise model, a multiple linear regression adjusted for covariates was performed. The final adjusted model contained four covariates: BMI and fat mass%. which were significantly different between groups below or above reference values for $VO_{2max}$ (Edvardsen et al., 2013), and gender and age were included, hence that these are covariates known to have a vital influence on $VO_{2max}$ (Bassett and Howley, 2000; Joyner & Lundby, 2018; Lee et al., 2010; Mezzani, 2017; Williams et al., 2017). To evaluate the precision of the non-exercise model, the multiple coefficient of determination ($R^2$) and the absolute standard error of estimate (SEE) was assessed. A Bland Altman plot was also performed to visually illustrate the agreement between measured $VO_{2max}$ and predicted $VO_{2max}$ from the non-exercise model at membership start-up and at follow-up.

# 5. RESULTS

## *5.1 Descriptive characteristics*

Background variables for all participants (n=125), and men (n = 62) and women (n=63) at membership start-up are presented in Table 3. Age ranged from 18-71 and 21-59 years among men and women, respectively (p=.04). In terms of BMI, 58 % of the men and 33% of the women were classified as overweight (BMI >25) (p=<.001). A total of 9.6% men and 9.5% women was classified with obesity (BMI>30) (p=.95). In terms of fat mass%, 45.5% of the participants had a fat mass% above reference values (p = 1.0).

The majority (82.4 %) of the participants was full-time employed, with gender differences (p=.05) (Table 3). A third of the participants had household gross income >850.000 NOK.

***Table 3:*** *Data are given for all participants and divided into women and men at membership start-up. Results are presented as mean (and standard deviation, SD) or number (and percentage), and p-value.*

| **Descriptives** | **Total (n=125)** | **Women (n=63)** | **Men (n=62)** | **Sig.** |
|---|---|---|---|---|
| Age (yrs) | 36.8 (±11.0) | 34.8 (±10.0) | 38.8 (±11.7) | .04 |
| Height (cm) | 174 (±10) | 167.4 (±5.8) | 182.4 (±7.2) | <.001 |
| Weight (kg) | 77.1 (±14.8) | 68.8 (±12.6) | 85.5 (±12.5) | <.001 |
| BMI (kg/m$^2$) | 25 (±3.9) | 24.6 (±4.5) | 25.6 (±3.2) | .13 |
| Fatt mass % | | | | |
| Smokes daily | 7 (5.6%) | 4 (6.3%) | 3 (4.8%) | .71 |
| Higher education >4 yrs | 57 (45.6%) | 31 (49.2%) | 26 (41.9%) | .08 |
| Employed | 103 (82.4%) | 46 (73%) | 57 (91.9%) | .005 |
| Household income *>850 000 NOK* | 41 (32.8%) | 19 (30.2%) | 22 (35.5%) | .526 |

BMI=Body mass index. Cpm=counts per minute. $VO_{2max}$= Maximal oxygen uptake. MVPA=Moderate-to-Vigorous-Physical Activity.

### 5.1.1 Total physical activity level

The majority of the participants met the current recommendations of 150 minutes of weekly MVPA at membership start-up (80%) and after 1-year follow-up (83%), respectively (Table 4). Mean minutes of vigorous PA was significantly lower at 1-year follow-up (22.7 minutes), compared with membership start-up (26.4 minutes, p = .002). The participants completed 6.4 (±1.6) and 6.0 (±1.5) days with valid activity recordings at membership start-up and follow-up, respectively (p=.02). Mean daily accelerometer wear time was 13.8 (±1.2) hours/d at both time points.

### 5.1.2 Physical fitness

Mean $VO_{2max}$ ($mL \cdot kg^{-1} \cdot min^{-1}$) was 37.8 (±7.2) and 39.95 (±8.4) at membership start-up and at 1-year follow-up, respectively (p=.093) (Table 4). More participants (42.9%) were above reference values for $VO_{2max}$ at 1-year follow-up, compared with membership start-up (32%, p=<.001).

### 5.1.3 Covariates

Mean fat mass% decreased from membership start-up to 1-year follow-up (mean difference: -1.72, p=.013) (Table 4). Gender was equally distributed at both time points (p=.92).

***Table 4:*** *The participants, total activity level, physical fitness and individual factors at membership start-up (n=125) and at 1-year follow-up (n=61). Results are presented as mean (and standard deviation, SD), and p-value.*

| | **Membership start-up** (n=125) | **1-Year follow-up** (n=61) | **Sig.** |
|---|---|---|---|
| Women/men (n) | 63/62 | 31/32 | .92 |
| Age (yrs) | 36.8 (±11.0) | 38.3 (±10.6) | .090 |
| BMI ($kg/m^2$) | 24.95 (±3.7) | 24.84 (±3.9) | .563 |
| Fat mass (%) | 24.84 (±8.7) | 23.11 (±9.7) | .013 |
| **Total physical activity level** | | | |
| *Accelerometer recording* | | | |
| Mean days | 6.4 (±1.6) | 6.0 (±1.5) | .02 |
| Hours/day | 13.8 (±1.2) | 13.8 (±1.2) | .08 |
| Total PA (cpm) | 357.0 (±113.6) | 375.8 (±123) | .23 |
| MVPA/weekly | 266.7 (±134.5) | 278.3 (±147) | .54 |
| *>150 min MVPA/weekly* | 100 (80 %) | 51 (83.6%) | .002 |
| Moderate PA (min) | 240.3 (±117) | 255.49 (±133) | .873 |
| Vigorous PA (min) | 26.4 (±37.8) | 22.7 (±43.8) | .002 |
| **Physical fitness** | | | |
| Time to exhaustion | 9.72 (±1.5) | 10.08 (±1.6) | .195 |
| $VO_{2max}$ ($mL \cdot kg^{-1} \cdot min^{-1}$) | 38.83 (±7.2) | 39.95 (±8.4) | .093 |
| $VO_{2max}$(L/min) | 2.89 (±0.7) | 3.07 (±0.8) | .027 |
| *>Refferance values for age groups* | 40 (32.%) | 27 (42.9%) | <.001 |
| Max heart rate | 179.4 (±21.3) | 180.7 (±12.7) | .31 |
| Borg scale (1-20) | 19.23 (±0.7) | 19.1 (±0.8) | .036 |
| RER | 1.37 (±.0.1) | 1.32 (±0.1) | <.001 |

BMI=Body mass index. Cpm=counts per minute. $VO_{2max}$= Maximal oxygen uptake. MVPA=Moderate-to-Vigorous-Physical Activity. RER=Respiratory Exchange Rate

## *5.2 Association between total activity level and maximal oxygen uptake*

Table 5 shows a correlation matrix of all independent factors and $VO_{2max.}$ All factors were significantly correlated with $VO_{2max}$ at membership start-up (p=<.05).

Table 6 shows results from the full multiple linear regression model, adjusted for covariates.

### 5.2.1 Total activity level (total cpm and minutes in MVPA)

At membership start-up, we observed a significant positive association between total cpm and $VO_{2max}$ (r(124) = .275, p=.001) as well as minutes in MVPA and $VO_{2max}$ (r(124)=.259, p=.002) (Table 5). No significant association was observed between total cpm and $VO_{2max}$ (r(60)=.198, p=.063), as well as minutes in MVPA and $VO_{2max}$ (r(60)=.123, p=.173) at one-year follow-up.

In the full model adjusted for covariates (BMI, fat mass%, gender and age), we observed no significant association between total cpm and $VO_{2max}$, or minutes in MVPA and $VO_{2max}$ at either of the time points (Table 6). Participants $VO_{2max}$ increased .001 $mL \cdot kg^{-1} \cdot min^{-1}$ for each minute of MVPA at membership start-up (p=.83). The opposite was found at follow-up, where $VO_{2max}$ decreased .006 $mL \cdot kg^{-1} \cdot min^{-1}$ for each increase in minutes of MVPA (p=.527). For every accumulated cpm, participants $VO_{2max}$ increased .009 $mL \cdot kg^{-1} \cdot min^{-1}$ at membership start-up (p=.08), and .016 $mL \cdot kg^{-1} \cdot min^{-1}$ at follow-up (p=.164) (Table 6).

### 5.2.2 Covariates (BMI, fat mass%, age and gender)

BMI, fat mass%, gender and age were all negatively associated with $VO_{2max}$ at membership start-up and at follow-up (p<.05) (Table 5). Fat mass% showed the greatest association at membership start-up (r(124)=-.716, p=<.001) and at follow-up (r(60)=-.626, p=<.001).

In the full model adjusted for covariates, age and fat mass% were significantly associated with $VO_{2max}$ at membership start-up, and age and gender were significantly associated with $VO_{2max}$ at follow-up. For each increase in year, there was a decrease of .243 $mL \cdot kg^{-1} \cdot min^{-1}$ in $VO_{2max}$ at membership start-up (p=<.001), and .263 $mL \cdot kg^{-1} \cdot min^{-1}$ at follow-up (p=<.001). For each increase in fat mass%, $VO_{2max}$ decreased .443 $mL \cdot kg^{-1} \cdot min^{-1}$ at membership start-up (p=<.001) and decreased with .138 $mL \cdot kg^{-1} \cdot min^{-1}$ at follow-up (p=.345).

Gender (female) was associated with a decrease of 2.017 mL·kg$^{-1}$·min$^{-1}$ in VO$_{2\text{max}}$ at membership start-up (p=.161) and 8.651 mL·kg$^{-1}$·min$^{-1}$ at follow-up (p=<.001). In the full model, BMI showed no significant association with VO$_{2\text{max}}$ at membership start up (p=.475) or at follow-up (p=.09).

***Table 5:*** *Correlation matrix of VO$_{2\text{max}}$ and independent factors at membership start-up (n=125) and after 1-year follow-up (n=61).*

**VO$_{2\text{max}}$ (mL·kg$^{-1}$·min$^{-1}$)**

| | **Membership start-up**<br>(n=125) | **1-year follow-up**<br>(n=61) |
|---|---|---|
| **Cpm** | .275** | .198 |
| **MVPA** | .259* | .123 |
| **BMI** | -.479** | -.367* |
| **Fat mass%** | -.716** | -.626 ** |
| **Gender** | -.382** | -.494** |
| **Age** | -.470** | -.324* |

BMI=Body Mass Index. Cpm=Counts Per Minute. MVPA=Moderate-to-Vigorous Physical Activity. P<.05* P<.001**

***Table 6:*** *Multiple linear regression for estimating VO$_{2\text{max}}$ at membership start-up (n=125) and at 1-year follow-up (n=61).*

**A multiple regression model for estimating VO$_{2\text{max}}$ (mL·kg$^{-1}$·min$^{-1}$)**

| | | **B** | **SE** | **T-score** | **95% CI** | |
|---|---|---|---|---|---|---|
| **Membership start-up** *(n=125)*<br>R$^2$=.690 **<br>SEE:4.084 | | | | | | |
| | **Constant** | 60.449 | 4.477 | 13.502 | 51.583 | 69.316 |
| | **Cpm** | .009 | .005 | 1.765 | -.001 | .020 |
| | **MVPA** | .001 | .005 | .213 | -.008 | .010 |
| | **BMI** | -.124 | .173 | -.717 | -465 | .218 |
| | **Fat mass%** | -.443** | .101 | -4.402 | -.643 | -.244 |
| | **Gender** | -2.017 | 1,429 | -1.412 | -4.846 | .813 |
| | **Age** | -.243** | .037 | -6.584 | -.316 | -.170 |
| **1-year follow-up** *(n=61)*<br>R$^2$=.588 **<br>SEE:5.6899 | | | | | | |
| | **Constant** | 74.410 | 8.557 | 8.696 | 57.247 | 91.573 |
| | **Cpm** | .016 | .012 | 1.410 | -.007 | .039 |
| | **MVPA** | -.006 | .010 | -.637 | -.025 | .013 |
| | **BMI** | -.523 | .303 | -1.726 | -1.130 | .085 |
| | **Fat mass%** | -.138 | ,145 | -.953 | -.430 | .153 |
| | **Gender** | -8.651** | 2,373 | -3.646 | -13.411 | -3.892 |
| | **Age** | -.263** | .071 | -3.726 | -.405 | -.121 |

BMI=Body Mass Index. Cpm=Counts Per Minute. MVPA=Moderate-to-Vigorous Physical Activity. SEE= Standard Error of Estimate. R$^2$= multiple coefficient of determination. P<.05* P<.001**

### 5.2.3 Predicted VO$_{2max}$ from a non-exercise model

Adjusted $R^2$ of the non-exercise model was high, and the six factors (total cpm, minutes in MVPA, BMI, fat mass%, gender and age), explained 69% (SEE= 4.084 mL·kg$^{-1}$·min$^{-1}$, p=<.001) and 58.8% (SEE= 5.6899 mL·kg$^{-1}$min$^{-1}$, p=<.001) of variance in measured VO$_{2max}$ at membership-start-up and at follow-up, respectively.

The Bland Altman plot demonstrates the difference between measured VO$_{2max}$ and predicted VO$_{2max}$ by the non-exercise model (total cpm, minutes in MVPA, BMI, fat mass%, age and gender) at membership start-up and at follow-up (Figure 2 and 3). Black and white dots represent participants above and below reference values for VO$_{2max}$ (Edvardsen et al., 2013), respectively.

At membership start-up, the non-exercise model overestimated on average VO$_{2max}$ by 0.0229 mL·kg$^{-1}$·min$^{-1}$- , with 95% confidence limits of agreement varying from + 7.791 to -7.837 mL·kg$^{-1}$·min$^{-1}$ (Figure 2). At 1-year follow-up, the non-exercise model underestimated VO$_{2max}$ by .0856 mL·kg$^{-1}$·min$^{-1}$, with 95% confidence limits of agreement varying from 10,760 to -10.931 (mL·kg$^{-1}$·min$^{-1}$). (Figure 3). Seven and five participants were outliers of the 95% limits of agreement at membership start-up and at follow-up, respectively.
We observed a significant difference in mean difference between participants above and below reference values for VO$_{2max}$ at both time points (p=<.001) (Figure 2 and 3).

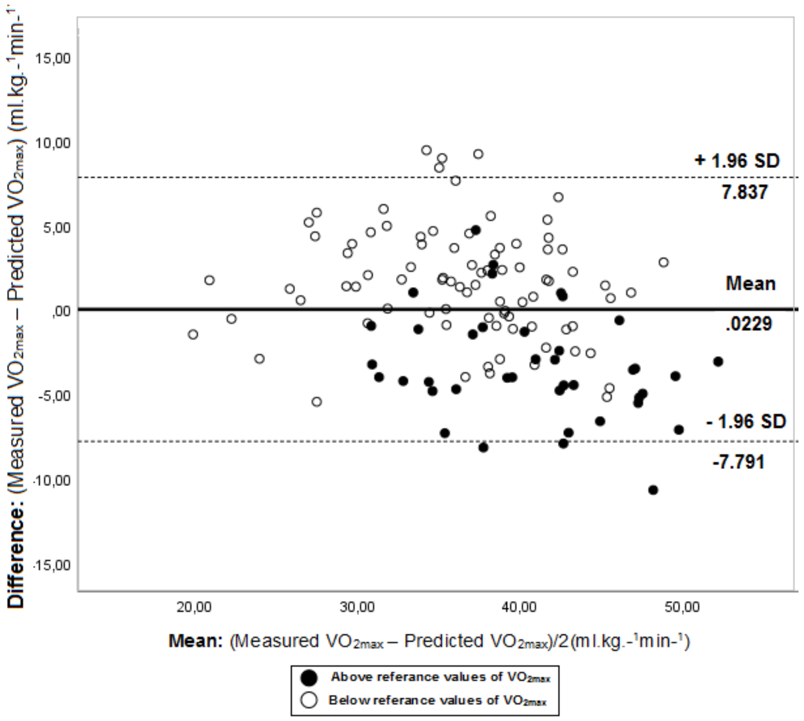

***Figure 2***: *Bland Altman plot illustrating the difference between predicted and measured VO$_{2max}$ at membership start-up (n=125). Mean difference and 95% limits of agreement (1.96 SD) are illustrated with straight and dotted lines, respectively. Black and white dots represent participants above and below reference values for VO$_{2max}$, respectively (Edvardsen et al., 2013).*

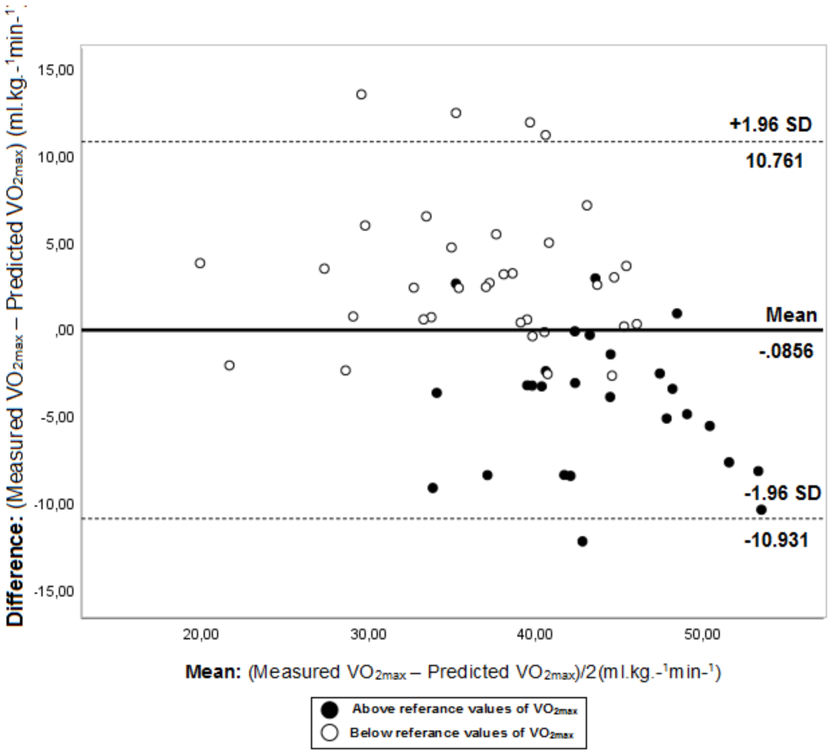

***Figure 3:*** *Bland Altman plot illustrating the difference between predicted and measured VO$_{2max}$ at follow-up (n=61). Mean difference and 95% limits of agreement (1.96 SD) are illustrated with straight and dotted lines, respectively. Black and white dots represent participants above and below reference values for VO$_{2max}$, respectively (Edvardsen et al., 2013).*

# 6. DISCUSSION

## *6.1 Results*

### 6.1.1 Main findings

Main findings in this study was that device-measured PA was significantly associated with $VO_{2max}$ at membership start-up, yet not at 1-year follow-up among untrained newly registered fitness club members. When adjusting for potential covariates (BMI, fat mass%, age and gender), no significant association was observed between total activity level and $VO_{2max}$ at membership start-up or at 1-year follow-up.

The non-exercise model explained 69% and 58.8% of variance in measured $VO_{2max}$ at membership start-up and at follow-up, respectively. Age and fat mass% were the strongest predictors for $VO_{2max}$ at membership start-up, and age and gender were the strongest predictors for $VO_{2max}$ at one-year follow-up.

### 6.1.2 Association between device-measured physical activity (MVPA and cpm) and maximal oxygen uptake

We observed that device-measured PA (minutes in MVPA and total cpm) were significantly associated with $VO_{2max}$ at membership start-up. However, when controlling for potential covariates (BMI, fat mass%, gender and age), minutes in MVPA and total cpm were not significantly associated with $VO_{2max}$ at either of the time points.

MVPA had the lowest correlation of all independent factors at membership start-up and at follow-up. This low correlation has been confirmed in previous research (Cao et al., 2010; Schembre & Riebe, 2011). Cpm showed a low, but significant correlation with $VO_{2max}$ at membership start-up. Compared with Dyrstad et al (2016) findings, we observed a stronger correlation between cpm and $VO_{2max}$. Yet, inconsistent with former research (Nes et al., 2011; Papathanasiou et al., 2010; Prioreschi et al., 2017; Schembre & Riebe, 2011), when adjusting for potential covariates, we found no significant association $VO_{2max}$ by total activity level (cpm) or minutes in MVPA at either of the time points.

### Low and high responders to Physical Activity

A source of bias in our findings are individual differences due to the genetical distribution of $VO_{2max}$. There are clear biological factors related to oxygen transport or muscular strength that is independent of PA habits (Joyner & Lundby, 2018). As previously referred, genetics may be responsible for as much as 50% of variation in measured $VO_{2max}$ (Bouchard & Rankinen, 2001; Nes et al., 2011), and a substantial proportion of participants in previous research has also been classified as non-responders (Bouchard & Rankinen, 2001; Hautala et al., 2006). Therefore, participants in this present study with high activity level, may not necessary be reflected by a high $VO_{2max.}$

When untrained, young and middle-aged participants engage in training program based on the current PA recommendations for 10-20 weeks, the increase in $VO_{2max}$ ranges from 0 to nearly 40-60% (Joyner & Lundby, 2018). The Heritage study (1995) reported that approximately 10-20% of participants responded only minimally to training with an increase in $VO_{2max}$, and consequently demonstrated limited or no trainability in response to a public health guideline-informed program (Joyner & Lundby, 2018; Skinner et al., 2001). Therefore, the adaption in $VO_{2max}$ is proven to be a subject of a large variation of high to low responders at all ages and in both genders. Thus, due to individual differences, the PA guideline recommendations may not be efficient enough to obtain an increase in $VO_{2max}$ for all individuals (Joyner & Lundby, 2018).

### Limited vigorous Physical Activity

The majority of research within this field, favors vigorous PA when investigating the association between activity level and $VO_{2max}$ (Aadahl et al., 2007; Dyrstad et al., 2016; Papathanasiou et al., 2010; Schembre & Riebe, 2011). Several studies has also not observed a significant association between activities with a moderate intensity and $VO_{2max}$ (Papathanasiou et al., 2010; Schembre & Riebe, 2011). Thus, this may be due to the fact that $VO_{2max}$ is greater influenced by vigorous PA (Ross et al., 2015; Swain, 2005; Swain & Franklin, 2006). Yet, in the present study, most of the participants conducted in moderate intensity PA. Mean minutes of vigorous PA was 26 min/week and 23 min/week at membership start-up and at follow-up, respectively. This is much lower than the current PA recommendations for vigorous PA (>75 minutes/week) (Helsedirektoratet, 2016; WHO, 2010). Still, we do not know if this low prevalence of vigorous PA is caused by accelerometers limitations in capturing vigorous PA (Brage, Wedderkopp, Franks, Bo Andersen & Froberg, 2003).

Participants with higher $VO_{2max}$ values at beginning of training, usually demand an intensity at >85% of maximal heart rate to achieve any improvement in $VO_{2max}$ (Lang et al., 2018). This would be classified as vigorous PA. Yet, Swain (2002) reported that no threshold was found among untrained participants (Swain, 2002). However, even though the participants in the present study was classified as untrained, was 32.8% and 42.9% of the current participants above references values specific for age and gender (Edvardsen et al., 2013) at membership start-up and at follow-up, respectively. Thus, we may speculate that for these participants, PA performed at higher intensity is needed to have an effect on their $VO_{2max}$ level. With regards to the possibility of non-responders on $VO_{2max}$, a randomized control trial by Ross et al (2015) found that for a fixed amount of exercise, increasing the intensity (from 50% to 75% of $VO_{2max}$) eliminated all non-responders on $VO_{2max}$, and stated that most healthy individuals are trainable, if training regimes at higher intensities are conducted (Ross et al., 2015). This underlines the importance of enhancing the general population to participate in vigorous PA as well as moderate intensity PA.

### Individual day-to-day variability and type of physical activty

The intra-individual day-to-day variability of PA may have influenced our findings (Warren et al., 2010). Physical fitness remains relatively static, or eventually improves over time, while PA can vary daily (Warren et al., 2010). The measurement periods may therefore not reflect the individual's total activity habits; hence it only gives a glance of the participants activity level from that particular week.

Since accelerometer does not measure type and aim of the activity, it is uncertain whether the participants conducted in any structured exercise during the measurement period, or if the total volume was incidental PA. Considering that mean minutes of vigorous PA was low at both time points, and the participants were categorized as untrained at membership start-up, there are reason to believe that some of the participants did not conduct in structured training within the two measurement periods. Even though incidental PA may have an positive influence on $VO_{2max}$ (McGuire & Ross, 2011), it will not improve $VO_{2max}$ in the same amount as structured training (Strath et al., 2013).

### Differences in measurement method

Another explanation to why we did not find an association between activity level and $VO_{2max}$ when adjusting for covariates as other studies have found, may be the use of different measurement methods when assessing activity level. Dyrstad et al (2014) found self-reported PA to overestimate device-measured PA with 54 minutes for moderate intensity PA and 13 minutes for vigorous intensity PA. This indicates a substantial difference between self-reported and device-measured PA (Dyrstad et al., 2014). Thus, it is not unexpected that our results somewhat differ from previously findings from self-report (Aadahl et al., 2007; Papathanasiou et al., 2010; Schembre & Riebe, 2011).

One study (Cao et al., 2010) who assessed device-measured PA, found steps per day to be significantly associated with $VO_{2max}$, when adjusting for covariates. Thus, we may have found different results if total steps per day were included in the full regression model. However, total cpm is the main unit when assessing total activity level (Dyrstad et al., 2014), and was therefore best suited for our research question. Further, sufficient minutes in MVPA is more relevant with regards to the current global recommendations for PA (Piercy et al., 2018; WHO,2010).

Two other studies (Kwon et al., 2019; Mundwiler et al., 2017) found components of device-measured activity level to be significantly associated with $VO_{2max}$ when adjusting for covariates. However, both of these studies assessed PA with a wrist-worn accelerometer, which is proven to have lower accuracy compared to hip placement (Arvidsson et al., 2019). The measurement period in Kwon et al (2019) study was also restricted to 3 days. Which may be too short to reflect the individuals activity level (Aadland & Ylvisåker, 2015; Trost et al., 2005).

### Inactive participants

Findings in this study may be biased due to inactive participants. We do not know if other results may have been found on more active participants. Even though 80% and 83.6% of the participants met the current PA recommendations (Piercy et al., 2018; WHO, 2010) at membership start-up and at follow-up respectively, it is essential to acknowledge that the present study did not excluded PA performed in bouts less than 10 minutes due to the updated PA recommendations (Piercy et al., 2018). A former study by Gjestvang et al (2019) studied the prevalence of participants meeting the previous PA recommendations (PA performed in bouts of >10 minutes, WHO, 2010) in the same participant group. The study found that 37.7% and 45.9% of the participants met ≥150 min weekly of MVPA at membership start-up and at follow-up, respectively. This prevalence was similar to the prevalence found in the general Norwegian adult population (Hansen et al., 2019; Helsedirektoratet, 2016*)*.

Hence, despite the prevalence of sufficiently active participants in this present study were high, there are reasons to believe that they were not as active as declared. Since we do not know what type of PA the participants conducted, and the occurrence of high and low responders on $VO_{2max}$ in the participant group, may not a high activity level be correspondingly associated with a high $VO_{2max}$ for all individuals. However, improved $VO_{2max}$ is not the only health outcome of sufficient PA. Still, there is substantiable evidence supporting the inverse relationship between PA and the risk developing disease and premature morality (Helsedirektoratet, 2016; Lee et al.,2012; Shiroma & Lee, 2010; WHO, 2010). Therefore, encouraging the population to be sufficient active should still be a prioritized health policy.

### 6.1.3 Covariates

**Body Mass Index and fat mass%**

High fat mass% seems to be greater associated with low $VO_{2max}$, compared with BMI.
Fat mass% showed the highest correlation with $VO_{2max}$ at both time points, and added significantly to the full regression model at membership start-up. A significant correlation between $VO_{2max}$ and fat mass% has been confirmed by Kwon et al (2019).
Former research has also established that fat mass% is a better predictor for risk of disease, since it reflects body composition, which BMI does not (Zeng et al., 2012). Furthermore, fat mass% is seen to be independently associated cardiovascular risk factors (Zeng et al., 2012).

In discrepancy, there is uncertainty if body mass itself, or the ratio between fat-free mass and lean body mass is the main influence on $VO_{2max}$. While one study concluded that only fat free mass, and not fat mass influences $VO_{2max}$ (Goran, Fields, Hunter, Herd & Weinster, 2000), found another study that $VO_{2max}$ decreased with obesity (Hulens, Vansant, Lysens, Claessens & Muls ,2001). However, Maciejcyk et al (2014) found that high body mass, regardless of cause, decreased $VO_{2max}$. Findings from "The National Health and Nutrition Examination survey" indicate a significant lower $VO_{2max}$ among individuals categorized with overweight and obesity (Wang et al., 2010). Thus, which was also shown in this present study, there is reason to believe high body fat will have a negative impact on $VO_{2max}$ values.

The relationship between fat mass% and $VO_{2max}$ may also be indirectly influenced by the individual's activity level. In general, more active individuals have a lower fat mass% compared with inactive individuals (Bradbury, Guo, Cairns, Armstrong & Key, 2017). Individuals categorized with obesity and overweight in the Norwegian population has also lower odds of meeting the current PA recommendations (Hansen et al., 2019). Thus, this may indirectly influence their $VO_{2max.}$

### Age

In line with former research (Cao et al., 2010; Kwon et al., 2019; Nes et al., 2011), age showed the greatest association with $VO_{2max}$ of all factors. Age was significantly correlated with $VO_{2max}$ at both time points. This correlation is confirmed by former research (Cao et al., 2010; Kwon et al., 2019). In the full regression model, age was the only factor that was significantly associated with $VO_{2max}$ at both time points. This is in line with Kwon et al (2019) findings, were 32% of variance in $VO_{2max}$ was explained by age only. Similarly, Nes et al (2011) concluded that age was the most potent determinant for $VO_{2max}$ values.

The decline of $VO_{2max}$ with increasing age is well documented in the literature (Anderssen et al., 2010; Berthouze et al., 1995; Betik & Hepple, 2008; Jackson et al., 1995; Jackson et al., 1996). For inactive individuals, $VO_{2max}$ is estimated to decline approximately 8% to 10% per decade after the age of 30 (Betik & Hepple, 2008; Edvardsen et al., 2013; Mezzani, 2017), and 20% per decade after the age of 70 (Betik & Hepple, 2008). This is mainly caused by decreasing maximal heart rate, reduced blood flow to skeletal muscles, reduces stroke volume and potential alterations in the so-called muscle diffusing capacity (Betik & Hepple, 2008).

However, an individual's activity level is also seen to decrease with increasing age (Betik & Hepple, 2008; Helsedirektoratet, 2016; WHO, 2010), which may in turn have a vital influence on $VO_{2max}$. Even though age is a non-modifiable factor, the decline in $VO_{2max}$ among active individuals is stated to be approximately half of the percentage for inactive individuals (Betik & Hepple, 2008).

**Gender**

Consistent with previous research (Aadahl et al., 2007; Prioreschi et al., 2017; Schembre & Riebe, 2011) we observed gender to predict a clear influence on $VO_{2max}$ among fitness club members. Female gender was negatively correlated with $VO_{2max}$ at both time points, and in the full regression model, gender was significantly associated with $VO_{2max}$ at follow-up. Thus, being male seems to be positively associated with higher $VO_{2max}$.

In this present study, was a gender difference of 2 ($mL \cdot kg^{-1} \cdot min^{-1}$) at membership start-up and 8.7 ($mL \cdot kg^{-1} \cdot min^{-1}$) at 1-year follow-up observed. In previous research with comparable aim, has a difference of 7.5 to 11.9 ($mL \cdot kg^{-1} \cdot min^{-1}$) between genders been found (Dyrstad et al., 2016; Mundwiler et al., 2017; Prioreschi et al., 2017; Schembre & Riebe, 2011). Also, in Norway, an average difference of 20-30% has been found between gender in every age group (Anderssen et al., 2010).

Though, the association between $VO_{2max}$ and gender in this present study was fairly greater at follow-up than at membership start-up, despite gender was equally distributed at both times. This may be due to the fact that mean difference in $VO_{2max}$ between gender was 2.8 ($mL \cdot kg^{-1} \cdot min^{-1}$) higher at follow-up than at membership start-up. However, there are reason to believe that this may be due to the reduction in sample size at follow-up. Since a higher risk of individual differences may occur (Kristman & Cote, 2004).

In contrast to previous research (Hansen et al., 2019; Prioreschi et al., 2017), no gender differences were observed in activity level at membership start-up or at follow-up. No gender differences were also not found in percentage of participants above or below reference values for $VO_{2max}$ (Edvardsen et al., 2013). This indicates that the gender differences found in the present study may be due to morphological and physiological differences between men and women (Berthouze et al., 1995; Mezzani, 2017). For instance, women have higher percentage of body fat, lower proportion of muscle and mitochondria mass, and lower hemoglobin concentration than men (Mezzani, 2017), which influences their physical fitness.

### 6.1.4 Predicted maximal oxygen uptake from a non-exercise model

The non-exercise model including time spent in MVPA, total cpm, BMI, fat mass%, gender and age, accounted for 69% and 58.8% of variance in measured $VO_{2max}$ at membership start-up and after 1-year of fitness club membership, respectively. Thus, the non-exercise model was more accurate at predicting the participants $VO_{2max}$ at membership start-up. Although, this may be caused by that more than half of the initial sample (51.2%) were lost to CPET at 1-year follow-up.

The six factors predicted variation in $VO_{2max}$ are consistent with findings found by former non-exercise models (Aadahl et al., 2007; Dyrstad et al., 2016; Mundwiler et al., 2017; Nes et al., 2011). Yet, we observed the non-exercise model to be a subject of large variation at the individual level. The mean difference between participants predicted and measured $VO_{2max}$ ranged from. 9.4 to -10.6 ($mL \cdot kg^{-1} \cdot min^{-1}$) at membership start-up and 13.5 to -12.2 ($mL \cdot kg^{-1} \cdot min^{-1}$) at follow-up. With regards to participants above and below reference values for $VO_{2max}$ (Edvardsen et al., 2013), the non-exercise model underestimated 90% and 84.6% of participants above reference values and overestimated 69% and 79% of participants below reference values for $VO_{2max}$ at membership start-up and at follow-up, respectively. This is consistent with former research indicating that non-exercise models to underestimate $VO_{2max}$ in trained participants, and overestimate $VO_{2max}$ in untrained participants (Jackson et al., 1990; Mathews et al., 1999; Schembre & Riebe, 2011).

The non-exercise model developed in this study did include individual factors that are shown to be the most dominant predictors for $VO_{2max}$ (Bassett & Howley, 2000; Betik & Hepple, 2008; Lee et al., 2010; Mezzani, 2017). However, due to the fact that non-exercise models do not account for genetic distribution, Nes et al (2011) stated that an observed variance above 60% may be as close as one may come with non-exercise models. The non-exercise model developed in this study may therefore be a feasible and useful tool for a rough estimate of $VO_{2max}$ when assessment of $VO_{2max}$ is not achievable.

## *6.2 Methodological considerations*

### 6.2.1 Study design

Data material in this master thesis was from the overall project “Fitness clubs – a venue for public health”, a longitudinal prospective study. A major strength with longitudinal studies is the ability to observe individual patterns of change (Belle, Fisher, Heagerty, Lumley, 2004 p.729). Since data is collected from individuals within a predefined group, we can analyze changes over time for the total group or for an individual (Song & Chung, 2010). In this present study, we were able to analyze if changes in the independent factors (minutes in MVPA and total cpm) covary with changes in the depended factor ($VO_{2max}$).

However, this study design also has some disadvantages. For instance, the risk of bias due to dropout of study participants (Belle et al., 2004 p.729). High drop-out rate can provide a follow-up sample that are not representative for the original target population (Belle et al., 2004 p.729), and loss of statistical power (Kristman & Cote, 2004). This study design is also sensitive to confounding factors, which are factors that can have an essential influence on the measured outcome (Caruana et al., 2015; Song & Chung,2010). To limit the influence by confounding factors in this present study, individual factors that was known to influence $VO_{2max}$ (age, gender and body composition and BMI) were included as covariates in the full regression model. This contributes to a measurement strength of the study.

### 6.2.2 Participants

Participation in the study was voluntary, and newly registered SATS ELIXIA members had to contact the research group to be included in the study. Only 275 of the total 6115 who received an email regarding the project contacted the research fellows.
Response rate for email surveys are influenced by personal interest of the participants, or if the participant rapports an email address they check at a frequently basis (Saleh & Bista, 2017). A potential explanation for this low participation rate is that all newly registered members received the email, regardless if they meet the inclusion criteria's or not. Another explanation might also be that newly members only received one mail, without further clarification regarding the project. Therefore, they might have forgotten to answer, or did not find the project relevant for them. We also speculate that new members already receive several emails regarding their new fitness club membership.

Our initial sample size of 125 at membership start-up are consistent with other studies with comparable aim (Aadahl et al., 2007; Cao et al., 2010; Papathanasiou et al., 2010). Yet, since more than half (n=64) of the participants were lost to 1-year follow-up, recruiting more participants could have been a potential strength of the study. Although, a follow-up sample of approximately 50% has been suggested as adequate (Kristman, Manno & Côté, 2004). Thus, our follow-up sample is within acceptable forms, yet below 70%, which is suggested as a decent follow-up sample (Kristman et al., 2004).

Even though our participants ranged in age and was equally gender distributed at both time points, they were homogenous with respect to ethnicity, and several of the participants had high socioeconomic status. One third had gross household income above 850000 NOK yearly. Monthly membership fees at SATS is also at average 659 NOK/monthly, which is more expensive compared with other fitness club chains in Oslo (*SATS, 2020*). It is reported that individuals with higher socioeconomic status are more likely to participate in PA, compared with individuals with lower socioeconomic status (Eime et al., 2015). Therefore, other results may have been found if the study was conducted at a low-cost fitness club chains, or if participants were from rural areas elsewhere than Oslo. However, SATS is one of the major fitness club centers in Oslo, and a large percentage of the population uses these respected fitness clubs

The study did also not observe a significant difference between above or below reference values for $VO_{2max}$ (Edvardsen et al., 2013) with gross household income, occupation or education level. Gjestvang and colleagues (2019) did also not find a significant difference in low or high exercise attendance to socioeconomic status on this participant group. Thus, there is reason to believe that socioeconomic status had a small impact on our current findings. A high percentage of the Norwegian adult population also has high socioeconomic status (FHI, 2018).

## *6.3 Measurements*

### 6.3.1 ActiGraph

The type of ActiGraph used in this present study was uniaxial. Therefore, it only measured movement in one axis, compared with ActiGraph GT3X, which allows triaxial data collection (Vanhelst et al., 2012). This may have underestimated movement in another axis than the vertical axis. Still, data are usually only obtained from the vertical axis in assessment of activity level (Chomistek et al., 2017). Measures by GT1M and GT3X are also showing similar results when collected in the uniaxial mode (Kaminsky & Ozemek, 2012; Sasaki, John, Freedson, 2011).

**Placement of the accelerometer**

Hip placed accelerometer has some limitations when accessing vigorous PA (Brage et al., 2003; Dyrstad et al., 2016). One study found that ActiGraph counts peaked when running speeds was at 10 km/h and started to even out when speed was increased (Brage et al., 2003). Hence, this measurement method may underestimate vigorous PA. One other study found that the sensitivity and specificity values for thigh-worn accelerometer were greater compared with wrist- or hip-worn accelerometers at all intensities of PA (Montoye, Pivarnik, Mudd, Biswas & Pfeiffer, 2016). In contrast, another study compared six different body placements, and found hip placement to be the optimal placement to capture a variety of activities (Cleland et al., 2013). As our participants were categorized as untrained at membership start-up, there is reasons that several of the participants did not conduct in vigorous running above 10 km/h. Hip placement is also more convenient when measuring free living PA (Arvidsson et al., 2019).

## Underestimation of activities

Since ActiGraph is an electro-mechanical device, this precludes their use for estimating energy expenditure in for instance water sports (McCurdy, 2015). They have also proven to be inaccurate for activities like cycling and resistance exercise. Particularly cycling and water sports are activities that may influence $VO_{2max}$ (McCurdy, 2015). Thus, this leads to a systematic under-estimation of MVPA in individuals that participates in these types of activities, and accelerometers are therefore best suited to evaluate activities involving walking or running (McCurdy, 2015). Although, the questionnaire in the overall research project did ask participants to report if they had conducted swimming, cycling or resistance training within the measurement period. If so, they were asked to report duration and frequency of the respected activities. Though, this study only compared device-measured activity level to $VO_{2max}$, hence, self-reported swimming, cycling or resistance training was not further analyzed.

ActiGraph does not register type or aim of the given activity, in contrast to for instance IPAQ (Dyrstad et al., 2014; Steene-Johannessen et al., 2016). The device can however determine intensity of the activity based on the given cut-points. Yet, even though there is no consensus regarding cut-points to determine the intensity of PA (Migueles et al., 2017), the current cut-points used in this present study are in line with average cut-points used for the adult population in prior PA research (Metzger et al., 2008; Migueles et al., 2017). Other studies with a comparable main aim have also used these respected cut-points (Dyrstad et al., 2016; Hansen et al., 2019; Prioreschi et al., 2017).

**Reactivity**

While wearing an accelerometer, the participants may be more aware of their activity habits, therefore achieve a higher activity level than under normal circumstances (Baumann et al., 2018). This is usually a result of social desirability, and is described as reactivity (Baumann et al., 2018; Davis & Lorpinizi, 2016). One study found a difference of 4% to 4.5% between first day, and second and third day of the intervention period (Davis & Loprinzi, 2016). However, the study concluded that there is not enough evidence supporting reactivity to influence the percentage of the population meeting the current PA recommendations (Davis & Loprinzi, 2016). This was confirmed by Baumann et al (2018), where minutes in MVPA was not influenced by accelerometer measured reactivity. This variation in PA level can also be caused by day-to-day variation of PA (Warren et al., 2010). Potential bias due to reactivity is also limited in this present study, since the participants underwent two measurement periods, in addition to mean days with valid measures was 6.4 days at membership start-up and 6.0 days at follow-up.

### 6.3.2 Cardiopulmonary exercise test

All CPETs were supervised by the same research fellow, which was essential to obtain inter-rater reliability. Further, as CPET is considered to be the gold standard to assess $VO_{2max}$, this may be considered a major strength of the present study (Schoffelen et al., 2019).

In litterature has a steady state at the end of the CPET been considered as a criteria to determine a true $VO_{2max}$ value (Beltz et al., 2016). Yet, since the modifed balke protcoll is a protocoll that not achive a “steady state” at the end of the test, it can be argued that our results are peak maximal oxygen uptake ($VO_{2peak}$) which is the highest physiological attainable value derived from a graded exercise test (Betlz et al., 2016). However, a valid exercise test was determined by end criteria’s such as a RER score between 1.10-1.30, as well as self-perceived exertion (Borg-scale) at >19 (Borg, 1970). Yet, there should be acknowledged, that when these parameters are used as a criteria for $VO_{2max}$ determination, they can underestimate the actual measured value with about 26% (Poole, Wilkerson & Jones, 2008). There is also individual day-to-day variability in human biology and motivation (Joyner & Lundby, 2018), which may influence the results on the current test-day. Thus, these two factors could eventually lead to a potential measurement bias of $VO_{2max}$ assessment.

### The stepwise modified Balke protocol

Since the present study aimed at recruiting untrained participants, the modified Balke protocol was a well-suited protocol. Hence, it gives a more modest increase in workload compared with other graded exercise protocols, and the initial speed is of low intensity (Aadland et al., 2017; Fletcher et al., 2013). Yet despite the Balke protocol being suiting for untrained participants, did some participants report that the CPETs was too painful due to exercising to volitional exhaustion. This feedback may be one of the explanations of the high drop-out rate (n=64) at 1-year follow-up.

However, this may be caused by the fact that the maximal test was assessed on a treadmill. CPETs conducted on a treadmill until exhaustion may not be suitable for individuals who have different health challenges related to pain or fatigue. Church et al (2007) concluded that maximal test conducted on a cycle ergometer were better tolerated for untrained participants. On the other side, treadmill protocols have several advantages over cycling protocols (Albouaini et al., 2007). It can also be argued that walking and running are universal activities, and the most frequently reported type of activities in the Norwegian population (Helsedirektoratet, 2016). This may also explain why treadmill protocols for measurement of $VO_{2max}$ can produce up to 20% greater $VO_{2max}$ values compared with cycling protocols (Beltz et al., 2016; Muscat et al., 2015).

Aadland et al (2017) stated that there is a lack of data on the reliability of the modified Balke protocol. The study found the protocol to be an accurate measure of $VO_{2max}$ on a group level across age and gender, while showing a substantiable amount of bias when assessing $VO_{2max}$ on an individual level (Aadland et al., 2017. Yet, another study compared cardiopulmonary responses between four protocols for maximal testing, including the Balke protocol (Pollock et al., 1976), and found no significant difference in $VO_{2max}$ achieved between the four protocols, despite the differences in $VO_2$ plateau. A pilot study conducted by Burchardt, Clark and Padrick (1989) also found the modified Balke protocol to be a suitable method for determining CRF in women with fibromyalgia. The participants were categorized as untrained, like the participants in this present study. The study had, however, a small number of participants (n=9).

The Balke protocol has also been used in previous larger studies who has included broad range of different individuals (Anderssen et al., 2010; Dyrstad et al., 2016; Edvardsen et al., 2013). For instance, the reference values for $VO_{2max}$ (Edvardsen et al., 2013) used in this present study was derived from a maximal treadmill test using a stepwise modified Balke protocol. Thus, since Edvardsen et al (2013) used the same protocol for $VO_{2max}$ assessment as this present study, this increased the comparability of $VO_{2max}$ values.

## *6.4 Practical implications and future research*

If we can predict $VO_{2max}$ by an easily accessible measure, this may have a major impact on future epidemiological studies. Hence, to do so in a public health setting, it is important to have an understanding of the factors influencing $VO_{2max}$.

To our knowledge, was this the first study to report longitudinal data with respect to the association between device-measured PA and $VO_{2max}$ in new, untrained fitness club members. Findings in this study indicates that there is not one principal cause for low or high $VO_{2max}$. Hence, $VO_{2max}$ is influenced by multiple factors, and genetics can cause a broad range of heterogenic in amount of adaption from health guideline-informed PA programs. This may also explain why the non-exercise model developed in this study showed a suitable amount of bias in predicting the participants $VO_{2max}$ at the individual level.

Since research on fitness club members and the association between device-measured PA and $VO_{2max}$ are limited to this present study, more should be conducted. For example, randomized controlled trials monitoring for $VO_{2max}$ genetical influence. Or combined self-reported PA with device-measured PA to investigate if different types of PA (occupational, leisure-time or incidental) are more associated with higher $VO_{2max}$. With regards to the fitness club context, other studies on low-cost fitness club chains, or in more rural areas outside of Oslo are also needed within this field. Hence a large percentage in Oslo have high socioeconomic status (FHI, 2018), which may have an influence on health and PA habits (Eime et al., 2015). The majority of the participants in this study also had low $VO_{2max.}$ Thus, more research is needed on both trained and untrained participants with high to low $VO_{2max}$ before any final conclusions can be drawn.

## *6.5 Strength and limitations*

Strong aspects of the present study were the use of a prospective longitudinal study design, enrollment of 125 participants, with an equal number of men and women, and a wide age specter. Furthermore, a valid and reliable graded exercise test (modified Balke protocol) was used to measure $VO_{2max}$, as well as a device-measurement method (Actigraph GT1M) to measure activity level, both contributing to reducing the risk of measurement error and improves study results reliability. The participants were also measured at two occasions. This may limit some of the risk of potential bias caused by day-to-day variability in activity level, and bias due to human biology and motivation, which may have an influence on the current test day when $VO_{2max}$ is assessed. Additionally, both minutes in MVPA and total cpm was used as metric of units to compare activity level with $VO_{2max}$ (Bassett et al., 2015), which therefore reflects total activity level and if the participants did or did not met the current PA recommendations (WHO, 2010).

The present study also had some limitations. The high number of participants lost to follow-up may contribute to lower methodical accuracy when participants were measured at one-year follow up. Further, since the accelerometer in this present study was uniaxial, it is likely to underestimate upper body and horizontal movements (such as cycling and resistance training). The measurement periods of PA may also not represent the participants PA habits, for instance due to day-to-day variability in PA level (Warren et al., 2010), and the measurement period only reflect the individual's activity level from that measured week. Therefore, the risk of measurement bias can still occur with device-measured PA.

Another potential bias in our study may be the high percentage of participants with high socioeconomic status and that the majority were of Norwegian descent. Hence, generalizing these findings to the overall Norwegian population might be limited, since the study sample was also narrowed to members at one fitness club chain in an urban area of Norway. Other findings may have occurred if we recruited a more diverse group, containing both untrained and trained individuals with low to high $VO_{2max}$.

# 7. CONCLUSION

At membership start-up, we found an association between device-measured PA (time spent in MVPA and total cpm) and $VO_{2max}$ in untrained new fitness club members. Yet, at one-year follow-up, no significant association was observed. When adjusting for covariates (BMI, fat mass%, age and gender), no association between device-measured PA and $VO_{2max}$ was found at either of the time points. Age, gender and fat mass% were the strongest predictors explaining $VO_{2max}$, and was stronger associated with $VO_{2max}$, compared with current PA level. However, these factors are also influenced by the individual's activity level. This underlines that the association between activity level and $VO_{2max}$ is complex, and there is not one principal cause for high or low $VO_{2max}$.

The non-exercise model including time spent in MVPA, total cpm, BMI, fat mass%, gender and age explained 69% and 58.8% of variance in measured $VO_{2max}$ among fitness club members at membership start-up and at follow-up, respectively. The non-exercise model developed in this study may be a feasible tool for establishing a rough estimate of $VO_{2max}$ at the group level among healthy and untrained fitness club members with generally low $VO_{2max}$ values.

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# LIST OF TABLES

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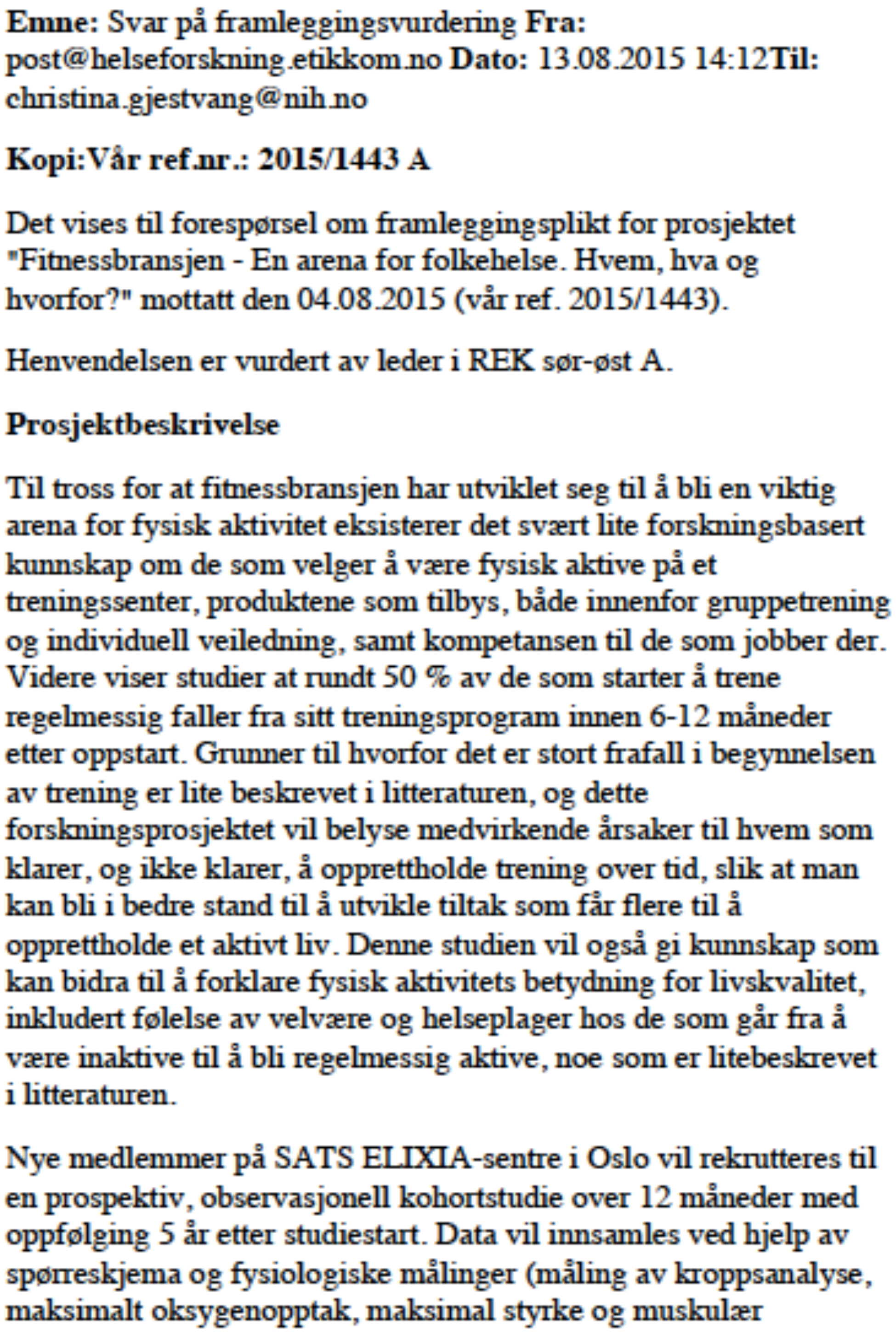
# APPENDIX 1: REVIEW BY REK



**Emne:** Svar på framleggingsvurdering **Fra:** post@helseforskning.etikkom.no **Dato:** 13.08.2015 14:12**Til:** christina.gjestvang@nih.no

**Kopi:Vår ref.nr.: 2015/1443 A**

Det vises til forespørsel om framleggingsplikt for prosjektet "Fitnessbransjen - En arena for folkehelse. Hvem, hva og hvorfor?" mottatt den 04.08.2015 (vår ref. 2015/1443).

Henvendelsen er vurdert av leder i REK sør-øst A.

**Prosjektbeskrivelse**

Til tross for at fitnessbransjen har utviklet seg til å bli en viktig arena for fysisk aktivitet eksisterer det svært lite forskningsbasert kunnskap om de som velger å være fysisk aktive på et treningssenter, produktene som tilbys, både innenfor gruppetrening og individuell veiledning, samt kompetansen til de som jobber der. Videre viser studier at rundt 50 % av de som starter å trene regelmessig faller fra sitt treningsprogram innen 6-12 måneder etter oppstart. Grunner til hvorfor det er stort frafall i begynnelsen av trening er lite beskrevet i litteraturen, og dette forskningsprosjektet vil belyse medvirkende årsaker til hvem som klarer, og ikke klarer, å opprettholde trening over tid, slik at man kan bli i bedre stand til å utvikle tiltak som får flere til å opprettholde et aktivt liv. Denne studien vil også gi kunnskap som kan bidra til å forklare fysisk aktivitets betydning for livskvalitet, inkludert følelse av velvære og helseplager hos de som går fra å være inaktive til å bli regelmessig aktive, noe som er litebeskrevet i litteraturen.

Nye medlemmer på SATS ELIXIA-sentre i Oslo vil rekrutteres til en prospektiv, observasjonell kohortstudie over 12 måneder med oppfølging 5 år etter studiestart. Data vil innsamles ved hjelp av spørreskjema og fysiologiske målinger (måling av kroppsanalyse, maksimalt oksygenopptak, maksimal styrke og muskulær utholdenhet) kartlagt ved baseline og etter 3, 6 og 12 mnd.

**Vurdering**

Etter REKs vurdering faller prosjektet slik det er beskrevet utenfor virkeområdet til helseforskningsloven. Helseforskningsloven gjelder for *medisinsk og helsefaglig forskning* på norsk territorium eller når forskningen skjer i regi av en forskningsansvarlig som er etablert i Norge.

Medisinsk og helsefaglig forskning er forskning på mennesker, humant biologisk materiale og helseopplysninger, som har som formål *å frambringe ny kunnskap om helse og sykdom*, jf. helseforskningsloven §§ 2 og 4a. Formålet er avgjørende, ikke om forskningen utføres av helsepersonell eller på pasienter eller benytter helseopplysninger.

Prosjektet er etter REKs vurdering et prosjekt som ikke har som formål å skaffe til veie ny kunnskap om helse og sykdom.

Prosjekter som faller utenfor helseforskningslovens virkeområde kan gjennomføres uten godkjenning av REK. Det er institusjonens ansvar på å sørge for at prosjektet gjennomføres på en forsvarlig måte med hensyn til for eksempel regler for taushetsplikt og personvern.

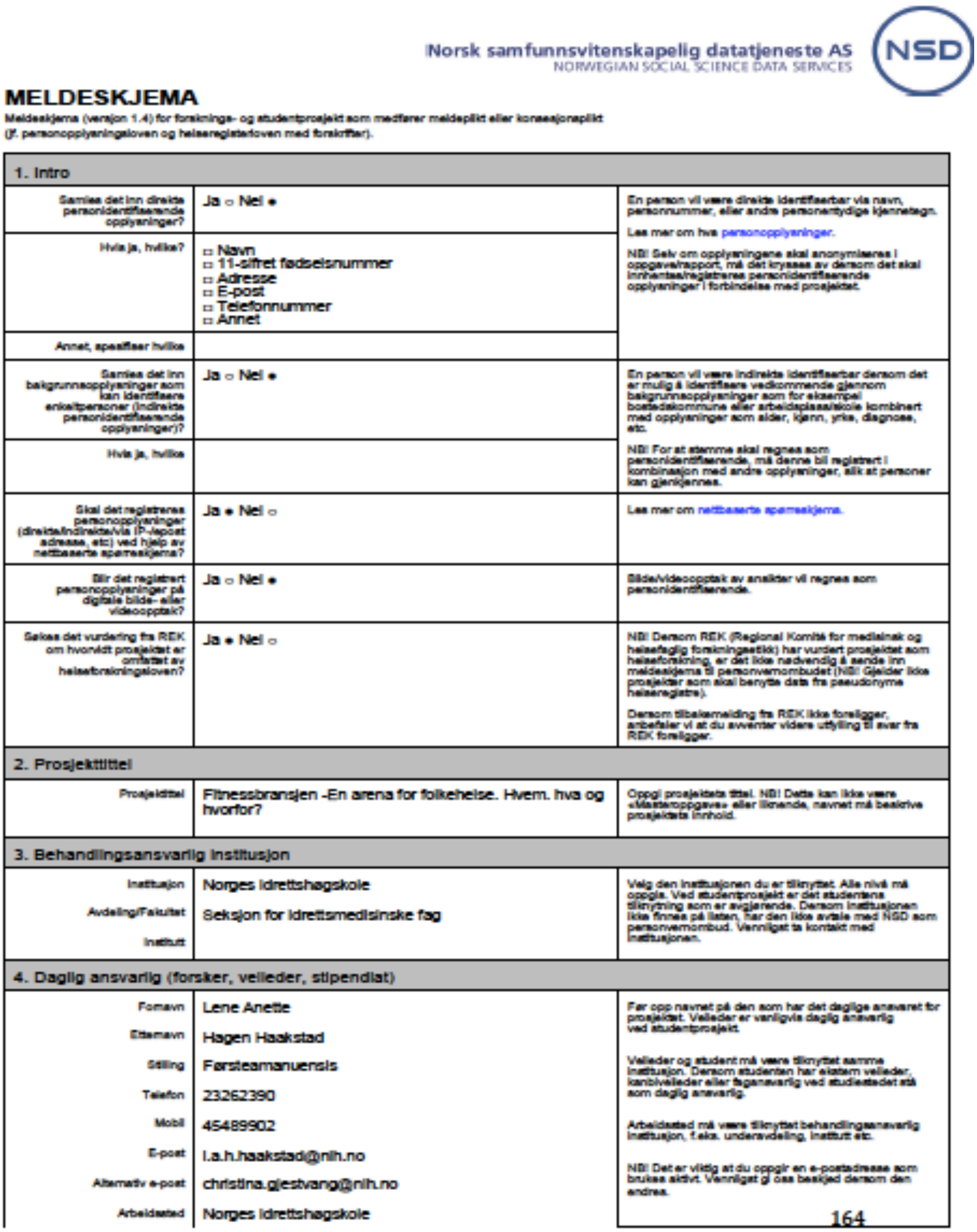
Vi gjør oppmerksom på at vurderingen og konklusjonen er å anse som veiledende jf. forvaltningsloven § 11.

Dersom dere likevel ønsker å søke REK vil søknaden bli behandlet i komitémøte, og det vil bli fattet et enkeltvedtak etter forvaltningsloven.

Med vennlig hilsenVivi Opdalseniorrådgiver
post@helseforskning.etikkom.no **T:** 22845526

**Regional komité for medisinsk og helsefaglig forskningsetikk**
**REK sør-øst-Norge (REK sør-øst)**
**http://helseforskning.etikkom.no**

# APPENDIX 2: APPLICATION FOR NSD



Norsk samfunnsvitenskapelig datatjeneste AS
NORWEGIAN SOCIAL SCIENCE DATA SERVICES
NSD

## MELDESKJEMA

Meldeskjema (versjon 1.4) for forsknings- og studentprosjekt som medfører meldeplikt eller konsesjonsplikt (jf. personopplysningsloven og helseregisterloven med forskrifter).

### 1. Intro

| | | |
|---|---|---|
| Samles det inn direkte personidentifiserende opplysninger? | Ja ○ Nei ● | En person vil være direkte identifiserbar via navn, personnummer, eller andre personentydige kjennetegn.<br>Les mer om hva personopplysninger.<br>NB! Selv om opplysningene skal anonymiseres i oppgave/rapport, må det krysses av dersom det skal innhentes/registreres personidentifiserende opplysninger i forbindelse med prosjektet. |
| Hvis ja, hvilke? | ☐ Navn<br>☐ 11-sifret fødselsnummer<br>☐ Adresse<br>☐ E-post<br>☐ Telefonnummer<br>☐ Annet | |
| Annet, spesifiser hvilke | | |
| Samles det inn bakgrunnsopplysninger som kan identifisere enkeltpersoner (indirekte personidentifiserende opplysninger)? | Ja ○ Nei ● | En person vil være indirekte identifiserbar dersom det er mulig å identifisere vedkommende gjennom bakgrunnsopplysninger som for eksempel bostedskommune eller arbeidsplass/skole kombinert med opplysninger som alder, kjønn, yrke, diagnose, etc.<br>NB! For at stemme skal regnes som personidentifiserende, må denne bli registrert i kombinasjon med andre opplysninger, slik at personer kan gjenkjennes. |
| Hvis ja, hvilke | | |
| Skal det registreres personopplysninger (direkte/indirekte/via IP-/epost adresse, etc) ved hjelp av nettbaserte spørreskjema? | Ja ● Nei ○ | Les mer om nettbaserte spørreskjema. |
| Blir det registrert personopplysninger på digitale bilde- eller videoopptak? | Ja ○ Nei ● | Bilde/videoopptak av ansikter vil regnes som personidentifiserende. |
| Søkes det vurdering fra REK om hvorvidt prosjektet er omfattet av helseforskningsloven? | Ja ● Nei ○ | NB! Dersom REK (Regional Komité for medisinsk og helsefaglig forskningsetikk) har vurdert prosjektet som helseforskning, er det ikke nødvendig å sende inn meldeskjema til personvernombudet (NB! Gjelder ikke prosjekter som skal benytte data fra pseudonyme helseregistre).<br>Dersom tilbakemelding fra REK ikke foreligger, anbefaler vi at du avventer videre utfylling til svar fra REK foreligger. |

### 2. Prosjekttittel

| | | |
|---|---|---|
| Prosjekttittel | Fitnessbransjen -En arena for folkehelse. Hvem. hva og hvorfor? | Oppgi prosjektets tittel. NB! Dette kan ikke være «Masteroppgave» eller liknende, navnet må beskrive prosjektets innhold. |

### 3. Behandlingsansvarlig institusjon

| | | |
|---|---|---|
| Institusjon | Norges idrettshøgskole | Velg den institusjonen du er tilknyttet. Alle nivå må oppgis. Ved studentprosjekt er det studentens tilknytning som er avgjørende. Dersom institusjonen ikke finnes på listen, har den ikke avtale med NSD som personvernombud. Vennligst ta kontakt med institusjonen. |
| Avdeling/Fakultet | Seksjon for idrettsmedisinske fag | |
| Institutt | | |

### 4. Daglig ansvarlig (forsker, veileder, stipendiat)

| | | |
|---|---|---|
| Fornavn | Lene Anette | Før opp navnet på den som har det daglige ansvaret for prosjektet. Veileder er vanligvis daglig ansvarlig ved studentprosjekt. |
| Etternavn | Hagen Haakstad | |
| Stilling | Førsteamanuensis | Veileder og student må være tilknyttet samme institusjon. Dersom studenten har ekstern veileder, kanbiveileder eller faganavarlig ved studiestedet stå som daglig ansvarlig. |
| Telefon | 23262390 | |
| Mobil | 45489902 | Arbeidssted må være tilknyttet behandlingsansvarlig institusjon, f.eks. underavdeling, institutt etc. |
| E-post | l.a.h.haakstad@nih.no | |
| Alternativ e-post | christina.gjestvang@nih.no | NB! Det er viktig at du oppgir en e-postadresse som brukes aktivt. Vennligst gi oss beskjed dersom den endres. |
| Arbeidssted | Norges idrettshøgskole | |

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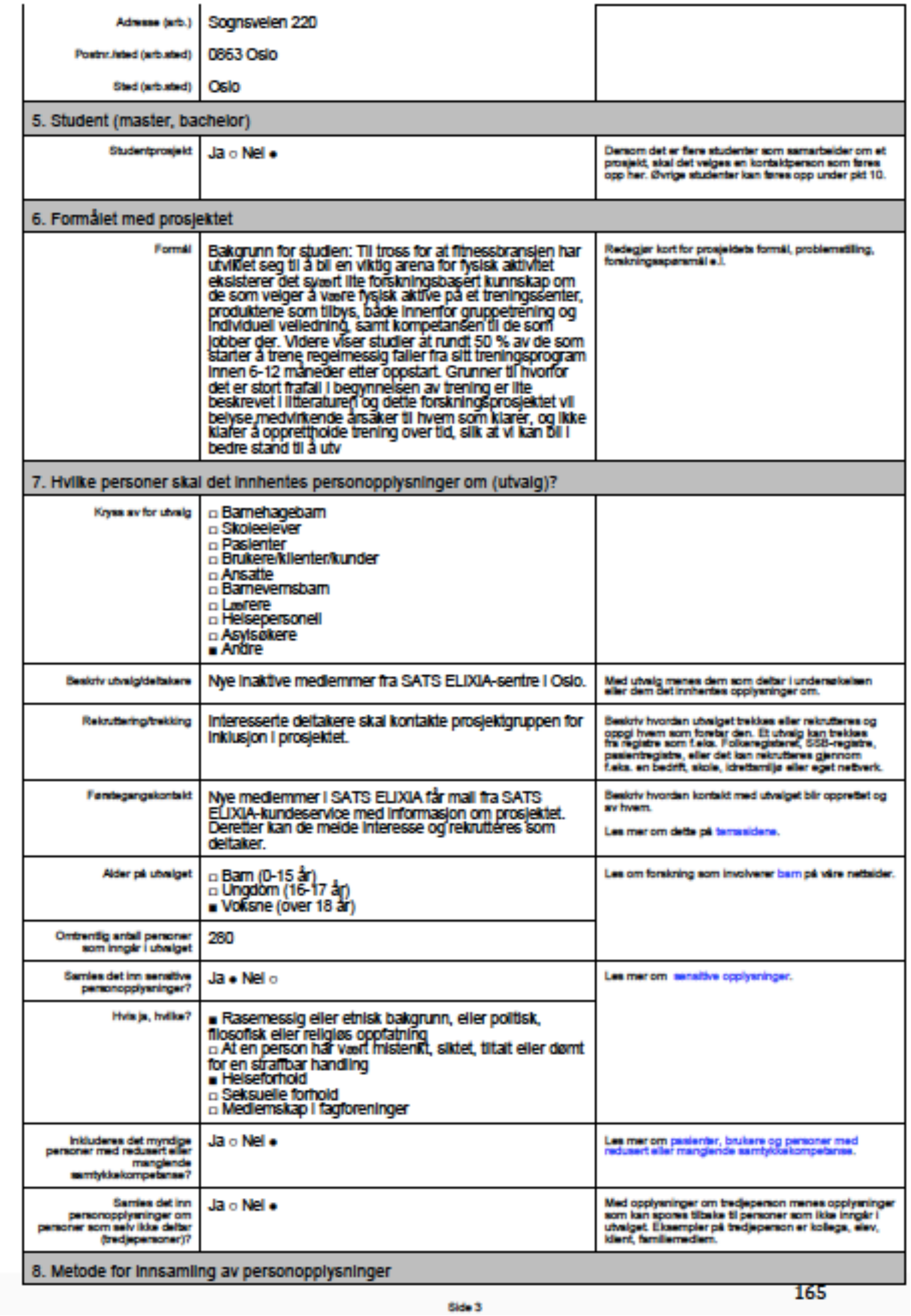

| | | |
|---|---|---|
| Adresse (arb.) | Sognsveien 220 | |
| Postnr./sted (arb.sted) | 0863 Oslo | |
| Sted (arb.sted) | Oslo | |

### 5. Student (master, bachelor)

| | | |
|---|---|---|
| Studentprosjekt | Ja ○ Nei ● | Dersom det er flere studenter som samarbeider om et prosjekt, skal det velges en kontaktperson som føres opp her. Øvrige studenter kan føres opp under pkt 10. |

### 6. Formålet med prosjektet

| | | |
|---|---|---|
| Formål | Bakgrunn for studien: Til tross for at fitnessbransjen har utviklet seg til å bli en viktig arena for fysisk aktivitet eksisterer det svært lite forskningsbasert kunnskap om de som velger å være fysisk aktive på et treningssenter, produktene som tilbys, både innenfor gruppetrening og individuell veiledning, samt kompetansen til de som jobber der. Videre viser studier at rundt 50 % av de som starter å trene regelmessig faller fra sitt treningsprogram innen 6-12 måneder etter oppstart. Grunner til hvorfor det er stort frafall i begynnelsen av trening er lite beskrevet i litteraturen og dette forskningsprosjektet vil belyse medvirkende årsaker til hvem som klarer, og ikke klarer å opprettholde trening over tid, slik at vi kan bli i bedre stand til å utv | Redegjør kort for prosjektets formål, problemstilling, forskningsspørsmål e.l. |

### 7. Hvilke personer skal det innhentes personopplysninger om (utvalg)?

| | | |
|---|---|---|
| Kryss av for utvalg | □ Barnehagebarn<br>□ Skoleelever<br>□ Pasienter<br>□ Brukere/klienter/kunder<br>□ Ansatte<br>□ Barnevernsbarn<br>□ Lærere<br>□ Helsepersonell<br>□ Asylsøkere<br>■ Andre | |
| Beskriv utvalg/deltakere | Nye inaktive medlemmer fra SATS ELIXIA-sentre i Oslo. | Med utvalg menes dem som deltar i undersøkelsen eller dem det innhentes opplysninger om. |
| Rekruttering/trekking | Interesserte deltakere skal kontakte prosjektgruppen for inklusjon i prosjektet. | Beskriv hvordan utvalget trekkes eller rekrutteres og oppgi hvem som foretar den. Et utvalg kan trekkes fra registre som f.eks. Folkeregisteret, SSB-registre, pasientregistre, eller det kan rekrutteres gjennom f.eks. en bedrift, skole, idrettsmiljø eller eget nettverk. |
| Førstegangskontakt | Nye medlemmer i SATS ELIXIA får mail fra SATS ELIXIA-kundeservice med informasjon om prosjektet. Deretter kan de melde interesse og rekrutteres som deltaker. | Beskriv hvordan kontakt med utvalget blir opprettet og av hvem.<br>Les mer om dette på temasidene. |
| Alder på utvalget | □ Barn (0-15 år)<br>□ Ungdom (16-17 år)<br>■ Voksne (over 18 år) | Les om forskning som involverer barn på våre nettsider. |
| Omtrentlig antall personer som inngår i utvalget | 280 | |
| Samles det inn sensitive personopplysninger? | Ja ● Nei ○ | Les mer om sensitive opplysninger. |
| Hvis ja, hvilke? | ■ Rasemessig eller etnisk bakgrunn, eller politisk, filosofisk eller religiøs oppfatning<br>□ At en person har vært mistenkt, siktet, tiltalt eller dømt for en straffbar handling<br>■ Helseforhold<br>□ Seksuelle forhold<br>□ Medlemskap i fagforeninger | |
| Inkluderes det myndige personer med redusert eller manglende samtykkekompetanse? | Ja ○ Nei ● | Les mer om pasienter, brukere og personer med redusert eller manglende samtykkekompetanse. |
| Samles det inn personopplysninger om personer som selv ikke deltar (tredjepersoner)? | Ja ○ Nei ● | Med opplysninger om tredjeperson menes opplysninger som kan spores tilbake til personer som ikke inngår i utvalget. Eksempler på tredjeperson er kollega, elev, klient, familiemedlem. |

### 8. Metode for innsamling av personopplysninger

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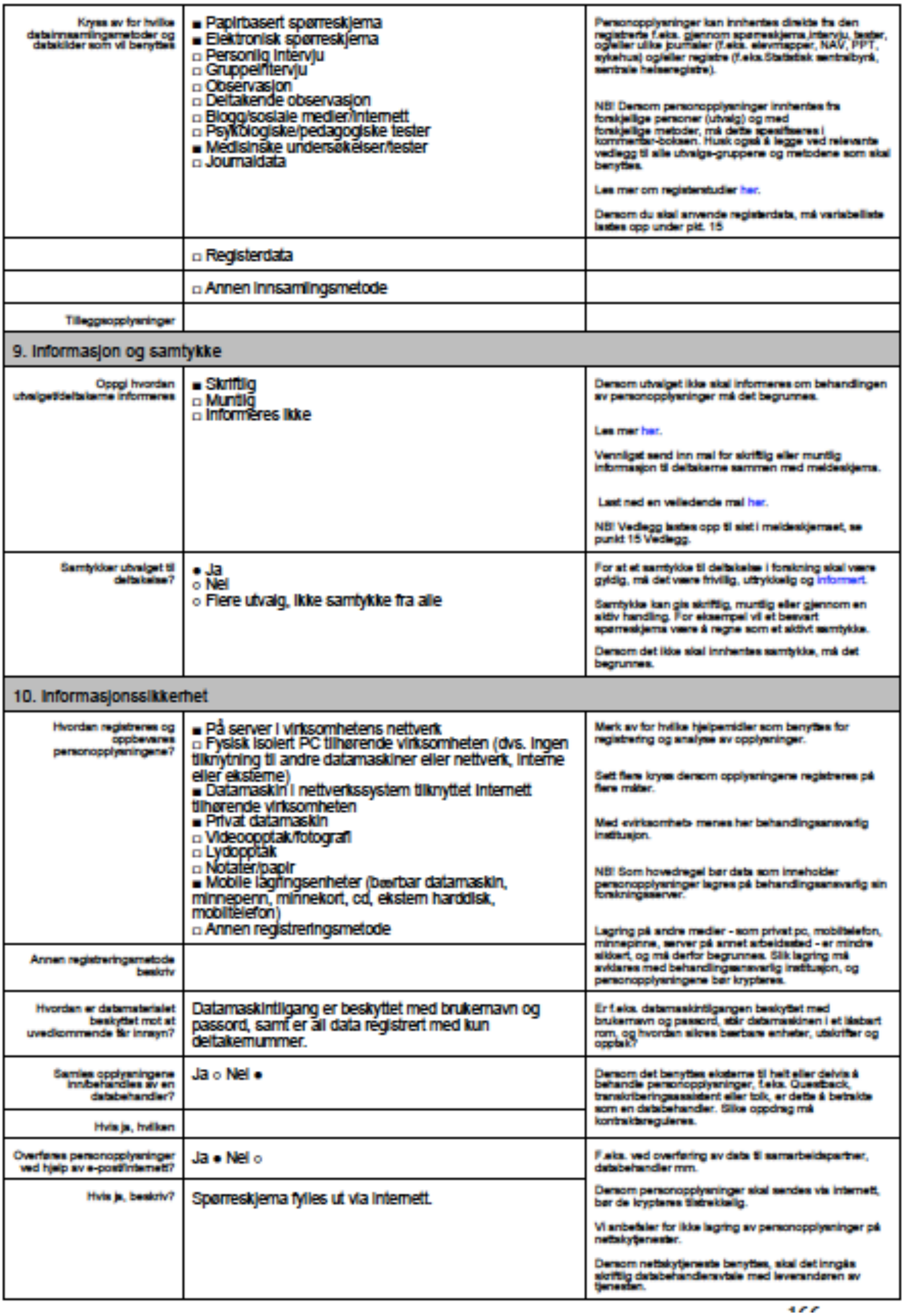
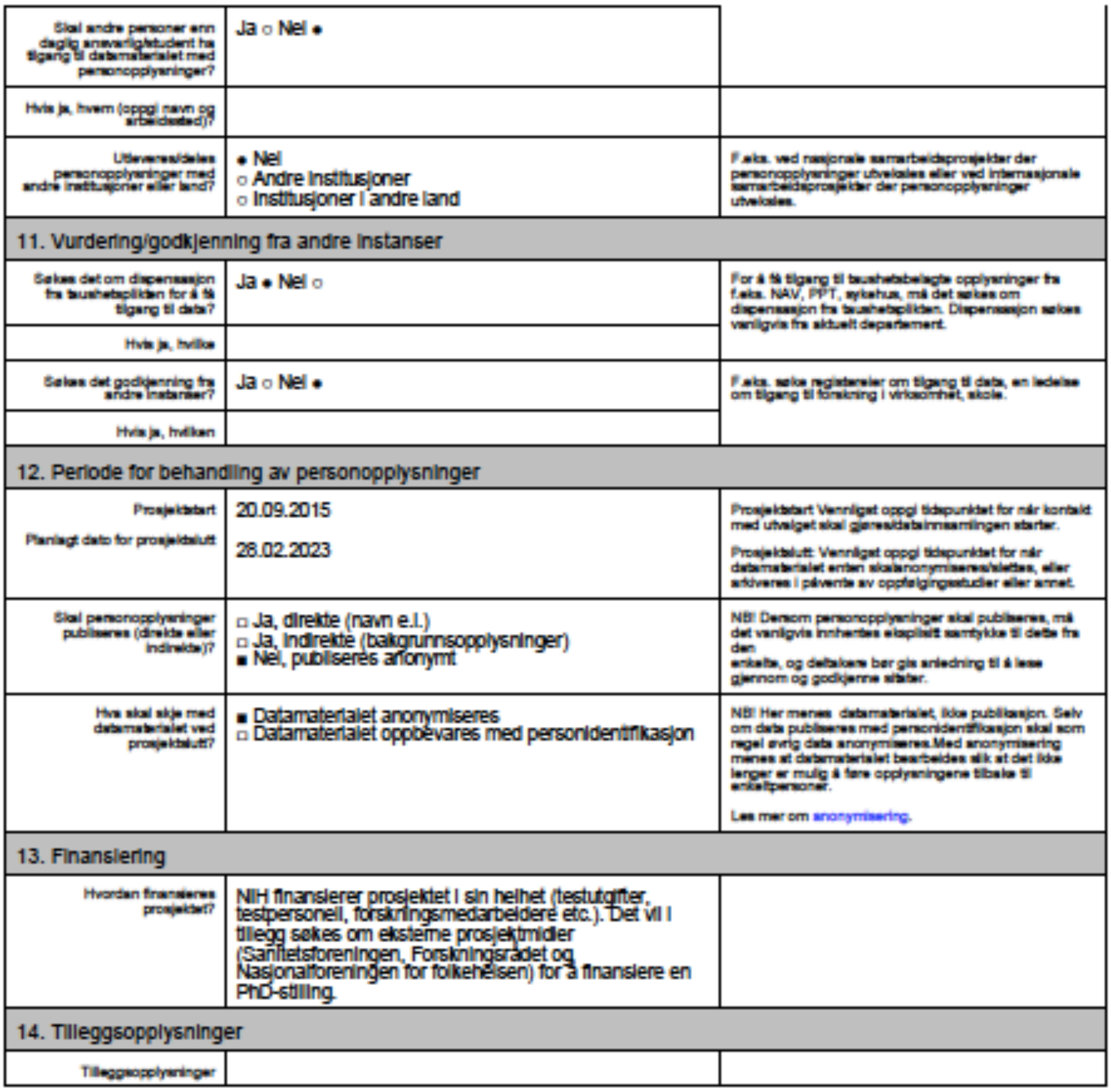


| | | |
|---|---|---|
| Kryss av for hvilke datainnsamlingsmetoder og datakilder som vil benyttes | ☒ Papirbasert spørreskjema<br>☒ Elektronisk spørreskjema<br>☐ Personlig intervju<br>☐ Gruppeintervju<br>☐ Observasjon<br>☐ Deltakende observasjon<br>☐ Blogg/sosiale medier/internett<br>☐ Psykologiske/pedagogiske tester<br>☒ Medisinske undersøkelser/tester<br>☐ Journaldata | Personopplysninger kan innhentes direkte fra den registrerte f.eks. gjennom spørreskjema,intervju, tester, og/eller ulike journaler (f.eks. elevmapper, NAV, PPT, sykehus) og/eller registre (f.eks.Statistisk sentralbyrå, sentrale helseregistre).<br>NB! Dersom personopplysninger innhentes fra forskjellige personer (utvalg) og med forskjellige metoder, må dette spesifiseres i kommentar-boksen. Husk også å legge ved relevante vedlegg til alle utvalgs-gruppene og metodene som skal benyttes.<br>Les mer om registerstudier her.<br>Dersom du skal anvende registerdata, må variabelliste lastes opp under pkt. 15 |
| | ☐ Registerdata | |
| | ☐ Annen innsamlingsmetode | |
| Tilleggsopplysninger | | |
| **9. Informasjon og samtykke** | | |
| Oppgi hvordan utvalget/deltakerne informeres | ☒ Skriftlig<br>☐ Muntlig<br>☐ Informeres ikke | Dersom utvalget ikke skal informeres om behandlingen av personopplysninger må det begrunnes.<br>Les mer her.<br>Vennligst send inn mal for skriftlig eller muntlig informasjon til deltakerne sammen med meldeskjema.<br>Last ned en veiledende mal her.<br>NB! Vedlegg lastes opp til sist i meldeskjemaet, se punkt 15 Vedlegg. |
| Samtykker utvalget til deltakelse? | ● Ja<br>○ Nei<br>○ Flere utvalg, ikke samtykke fra alle | For at et samtykke til deltakelse i forskning skal være gyldig, må det være frivillig, uttrykkelig og informert.<br>Samtykke kan gis skriftlig, muntlig eller gjennom en aktiv handling. For eksempel vil et besvart spørreskjema være å regne som et aktivt samtykke.<br>Dersom det ikke skal innhentes samtykke, må det begrunnes. |
| **10. Informasjonssikkerhet** | | |
| Hvordan registreres og oppbevares personopplysningene? | ☒ På server i virksomhetens nettverk<br>☐ Fysisk isolert PC tilhørende virksomheten (dvs. ingen tilknytning til andre datamaskiner eller nettverk, interne eller eksterne)<br>☒ Datamaskin i nettverkssystem tilknyttet Internett tilhørende virksomheten<br>☒ Privat datamaskin<br>☐ Videoopptak/fotografi<br>☐ Lydopptak<br>☐ Notater/papir<br>☒ Mobile lagringsenheter (bærbar datamaskin, minnepenn, minnekort, cd, ekstern harddisk, mobiltelefon)<br>☐ Annen registreringsmetode | Merk av for hvilke hjelpemidler som benyttes for registrering og analyse av opplysninger.<br>Sett flere kryss dersom opplysningene registreres på flere måter.<br>Med «virksomhet» menes her behandlingsansvarlig institusjon.<br>NB! Som hovedregel bør data som inneholder personopplysninger lagres på behandlingsansvarlig sin forskningsserver.<br>Lagring på andre medier - som privat pc, mobiltelefon, minnepinne, server på annet arbeidssted - er mindre sikkert, og må derfor begrunnes. Slik lagring må avklares med behandlingsansvarlig institusjon, og personopplysningene bør krypteres. |
| Annen registreringsmetode beskriv | | |
| Hvordan er datamaterialet beskyttet mot at uvedkommende får innsyn? | Datamaskintilgang er beskyttet med brukernavn og passord, samt er all data registrert med kun deltakernummer. | Er f.eks. datamaskintilgangen beskyttet med brukernavn og passord, står datamaskinen i et låsbart rom, og hvordan sikres bærbare enheter, utskrifter og opptak? |
| Samles opplysningene inn/behandles av en databehandler? | Ja ○ Nei ● | Dersom det benyttes eksterne til helt eller delvis å behandle personopplysninger, f.eks. Questback, transkriberingsassistent eller tolk, er dette å betrakte som en databehandler. Slike oppdrag må kontraktsreguleres. |
| Hvis ja, hvilken | | |
| Overføres personopplysninger ved hjelp av e-post/Internett? | Ja ● Nei ○ | F.eks. ved overføring av data til samarbeidspartner, databehandler mm.<br>Dersom personopplysninger skal sendes via internett, bør de krypteres tilstrekkelig.<br>Vi anbefaler for ikke lagring av personopplysninger på nettskytjenester.<br>Dersom nettskytjeneste benyttes, skal det inngås skriftlig databehandleravtale med leverandøren av tjenesten. |
| Hvis ja, beskriv? | Spørreskjema fylles ut via Internett. | |



| | | |
|---|---|---|
| Skal andre personer enn daglig ansvarlig/student ha tilgang til datamaterialet med personopplysninger? | Ja ○ Nei ● | |
| Hvis ja, hvem (oppgi navn og arbeidssted)? | | |
| Utleveres/deles personopplysninger med andre institusjoner eller land? | ● Nei<br>○ Andre institusjoner<br>○ Institusjoner i andre land | F.eks. ved nasjonale samarbeidsprosjekter der personopplysninger utveksles eller ved internasjonale samarbeidsprosjekter der personopplysninger utveksles. |

## 11. Vurdering/godkjenning fra andre instanser

| | | |
|---|---|---|
| Søkes det om dispensasjon fra taushetsplikten for å få tilgang til data? | Ja ● Nei ○ | For å få tilgang til taushetsbelagte opplysninger fra f.eks. NAV, PPT, sykehus, må det søkes om dispensasjon fra taushetsplikten. Dispensasjon søkes vanligvis fra aktuelt departement. |
| Hvis ja, hvilke | | |
| Søkes det godkjenning fra andre instanser? | Ja ○ Nei ● | F.eks. søke registereier om tilgang til data, en ledelse om tilgang til forskning i virksomhet, skole. |
| Hvis ja, hvilken | | |

## 12. Periode for behandling av personopplysninger

| | | |
|---|---|---|
| Prosjektstart<br>Planlagt dato for prosjektslutt | 20.09.2015<br>28.02.2023 | Prosjektstart Vennligst oppgi tidspunktet for når kontakt med utvalget skal gjøres/datainnsamlingen starter.<br>Prosjektslutt: Vennligst oppgi tidspunktet for når datamaterialet enten skalanonymiseres/slettes, eller arkiveres i påvente av oppfølgingsstudier eller annet. |
| Skal personopplysninger publiseres (direkte eller indirekte)? | ☐ Ja, direkte (navn e.l.)<br>☐ Ja, indirekte (bakgrunnsopplysninger)<br>■ Nei, publiseres anonymt | NB! Dersom personopplysninger skal publiseres, må det vanligvis innhentes eksplisitt samtykke til dette fra den enkelte, og deltakere bør gis anledning til å lese gjennom og godkjenne sitater. |
| Hva skal skje med datamaterialet ved prosjektslutt? | ■ Datamaterialet anonymiseres<br>☐ Datamaterialet oppbevares med personidentifikasjon | NB! Her menes datamaterialet, ikke publikasjon. Selv om data publiseres med personidentifikasjon skal som regel øvrig data anonymiseres.Med anonymisering menes at datamaterialet bearbeides slik at det ikke lenger er mulig å føre opplysningene tilbake til enkeltpersoner.<br>Les mer om anonymisering. |

## 13. Finansiering

| | | |
|---|---|---|
| Hvordan finansieres prosjektet? | NIH finansierer prosjektet i sin helhet (testutgifter, testpersonell, forskringsmedarbeidere etc.). Det vil i tillegg søkes om eksterne prosjektmidler (Sanitetsforeningen, Forskningsrådet og Nasjonalforeningen for folkehelsen) for å finansiere en PhD-stilling. | |

## 14. Tilleggsopplysninger

| | | |
|---|---|---|
| Tilleggsopplysninger | | |

# APPENDIX 3: APPROVAL FROM NSD

**Norsk samfunnsvitenskapelig datatjeneste AS**
NORWEGIAN SOCIAL SCIENCE DATA SERVICES

NSD
Harald Hårfagres gate 29
N-5007 Bergen
Norway
Tel: +47-55 58 21 17
Fax: +47-55 58 96 50
nsd@nsd.uib.no
www.nsd.uib.no
Org.nr. 985 321 884

Lene A.H. Haakstad
Seksjon for idrettsmedisinske fag Norges idrettshøgskole
Postboks 4014 Ullevål Stadion
0806 OSLO

Vår dato: 02.09.2015 Vår ref: 44135 / 3 / LT Deres dato: Deres ref:

TILBAKEMELDING PÅ MELDING OM BEHANDLING AV PERSONOPPLYSNINGER

Vi viser til melding om behandling av personopplysninger, mottatt 04.08.2015. Meldingen gjelder prosjektet:

| | |
|---|---|
| *44135* | *Fitnessbransjen -En arena for folkehelse. Hvem, hva og hvorfor?* |
| *Behandlingsansvarlig* | *Norges idrettshøgskole, ved institusjonens øverste leder* |
| *Daglig ansvarlig* | *Lene A.H. Haakstad* |

Personvernombudet har vurdert prosjektet, og finner at behandlingen av personopplysninger vil være regulert av § 7-27 i personopplysningsforskriften. Personvernombudet tilrår at prosjektet gjennomføres.

Personvernombudets tilråding forutsetter at prosjektet gjennomføres i tråd med opplysningene gitt i meldeskjemaet, korrespondanse med ombudet, ombudets kommentarer samt personopplysningsloven og helseregisterloven med forskrifter. Behandlingen av personopplysninger kan settes i gang.

Det gjøres oppmerksom på at det skal gis ny melding dersom behandlingen endres i forhold til de opplysninger som ligger til grunn for personvernombudets vurdering. Endringsmeldinger gis via et eget skjema, http://www.nsd.uib.no/personvern/meldeplikt/skjema.html. Det skal også gis melding etter tre år dersom prosjektet fortsatt pågår. Meldinger skal skje skriftlig til ombudet.

Personvernombudet har lagt ut opplysninger om prosjektet i en offentlig database, http://pvo.nsd.no/prosjekt.

Personvernombudet vil ved prosjektets avslutning, 28.02.2023, rette en henvendelse angående status for behandlingen av personopplysninger.

Vennlig hilsen

Katrine Utaaker Segadal

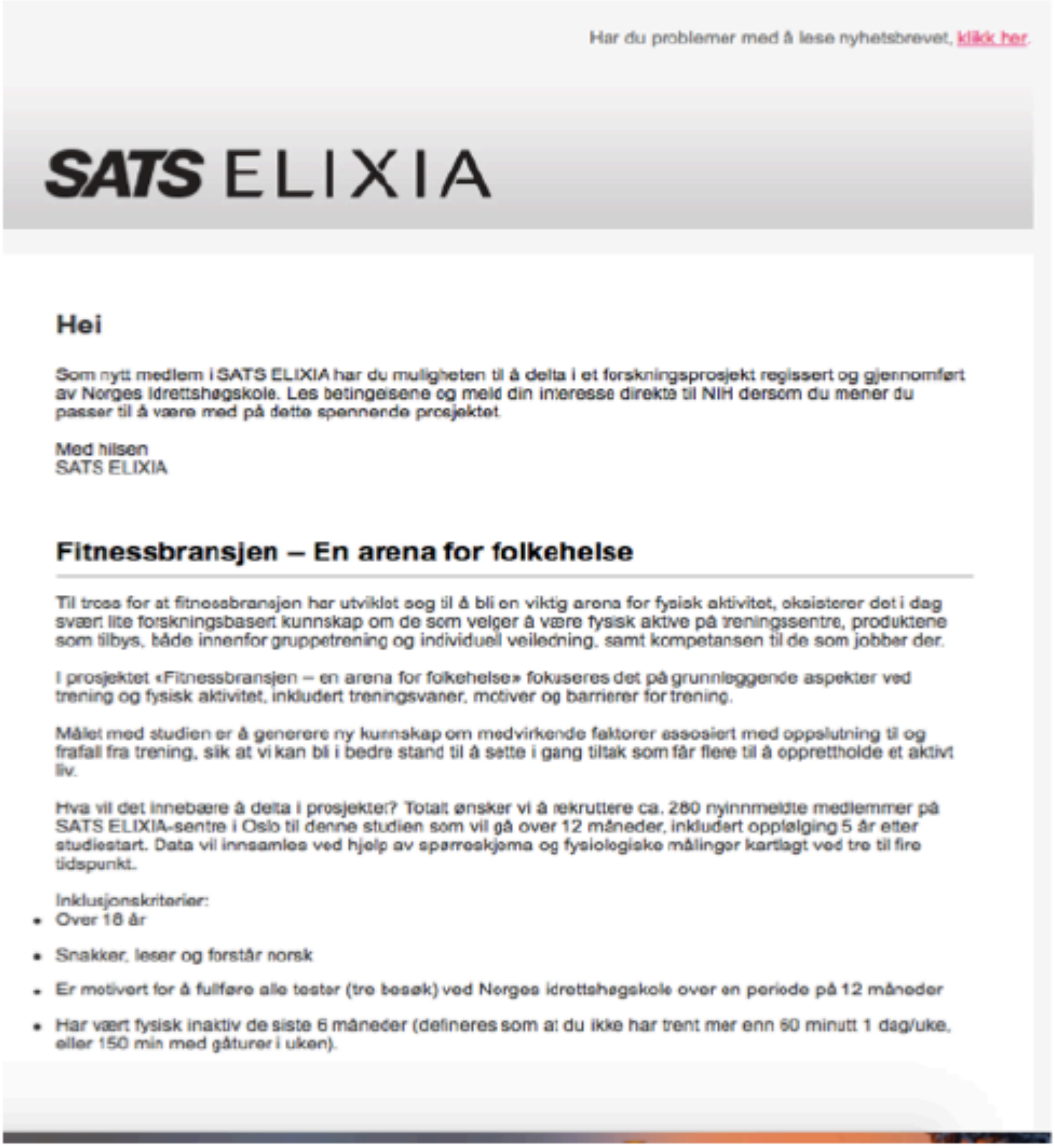
Lis Tenold

Kontaktperson: Lis Tenold tlf: 55 58 33 77
Vedlegg: Prosjektvurdering

*Dokumentet er elektronisk produsert og godkjent ved NSDs rutiner for elektronisk godkjenning.*

*Avdelingskontorer / District Offices:*
OSLO: NSD. Universitetet i Oslo, Postboks 1055 Blindern, 0316 Oslo. Tel: +47-22 85 52 11. nsd@uio.no
TRONDHEIM: NSD. Norges teknisk-naturvitenskapelige universitet, 7491 Trondheim. Tel: +47-73 59 19 07. kyrre.svarva@svt.ntnu.no
TROMSØ: NSD. SVF, Universitetet i Tromsø, 9037 Tromsø. Tel: +47-77 64 43 36. nsdmaa@sv.uit.no

# APPENDIX 4: EMAIL INVITATION FOR NEWLY REGISTERED FITNESS CLUB MEMBERS



Har du problemer med å lese nyhetsbrevet, klikk her.

SATS ELIXIA

## Hei

Som nytt medlem i SATS ELIXIA har du muligheten til å delta i et forskningsprosjekt regissert og gjennomført av Norges Idrettshøgskole. Les betingelsene og meld din interesse direkte til NIH dersom du mener du passer til å være med på dette spennende prosjektet.

Med hilsen
SATS ELIXIA

## Fitnessbransjen – En arena for folkehelse

Til tross for at fitnessbransjen har utviklet seg til å bli en viktig arena for fysisk aktivitet, eksisterer det i dag svært lite forskningsbasert kunnskap om de som velger å være fysisk aktive på treningssentre, produktene som tilbys, både innenfor gruppetrening og individuell veiledning, samt kompetansen til de som jobber der.

I prosjektet «Fitnessbransjen – en arena for folkehelse» fokuseres det på grunnleggende aspekter ved trening og fysisk aktivitet, inkludert treningsvaner, motiver og barrierer for trening.

Målet med studien er å generere ny kunnskap om medvirkende faktorer assosiert med oppslutning til og frafall fra trening, slik at vi kan bli i bedre stand til å sette i gang tiltak som får flere til å opprettholde et aktivt liv.

Hva vil det innebære å delta i prosjektet? Totalt ønsker vi å rekruttere ca. 280 nyinnmeldte medlemmer på SATS ELIXIA-sentre i Oslo til denne studien som vil gå over 12 måneder, inkludert oppfølging 5 år etter studiestart. Data vil innsamles ved hjelp av spørreskjema og fysiologiske målinger kartlagt ved tre til fire tidspunkt.

Inklusjonskriterier:
- Over 18 år
- Snakker, leser og forstår norsk
- Er motivert for å fullføre alle tester (tre besøk) ved Norges idrettshøgskole over en periode på 12 måneder
- Har vært fysisk inaktiv de siste 6 måneder (defineres som at du ikke har trent mer enn 60 minutt 1 dag/uke, eller 150 min med gåturer i uken).

## Gratis test av fysisk form!

Testingen vil foregå på Norges idrettshøgskole (NIH), og vil ta ca. 1 time og 30 minutter hver gang og inkluderer følgende prosedyre:

Baseline, 3 or 12 måneder
- Spørreskjema om fysisk aktivitet/trening, kosthold, helse, livskvalitet og sosial støtte (tar ca. 20 minutter å fylle ut)

- Måling av kroppssammensetning (fettmasse og muskelmasse) med Inbody

- Måling av maksimalt oksygenopptak med indirekte kalorimetri («Breath by breath»)

- Måling av styrke og muskulær utholdenhet inkludert 1RM test (Repetisjon Maksimum) i benpress (underkropp) og benkpress (underkropp). Det vil også gjennomføres styrketester med 70 % belastning av 1 RM i de samme øvelsene.

Baseline og 12 måneder
Objektiv kartlegging av totalt fysisk aktivitetsnivå med ActiGraph GT1M. Du vil bære akselerometeret i en uke (7 dager) ved hver måleperiode.

Seks måneder
Spørreskjema om fysisk aktivitet/trening, kosthold, helse, livskvalitet og sosial støtte vil sendes elektronisk til alle deltagere.

*Alle testene benyttes hyppig innen forskning og idrettsmedisin, og innebærer liten risiko for skader og negativ påvirkning for deg. Kroppssammensetning måles med Inbody som gir en beskjeden stråledose. Testing av maksimal styrke, muskulær utholdenhet og oksygenopptak (VO2max) følger standard prosedyrer ved NIH, og vil gjennomføres av erfarne testledere.*

*Gjennomføring av tester og deltakelse i prosjektet er selvsagt uten kostnader for deg. Kostnader i forbindelse med transport til og fra testing dekkes ikke.*

*Deltagelse er helt frivillig, og du har anledning til å trekke deg fra prosjektet når du måtte ønske det, uten å måtte oppgi grunn. Alle resultater vil bli behandlet konfidensielt, og kun kodenummer, ikke navn, vil bli lagt inn på datamaskin for videre analyser. Prosjektet er vurdert av Personvernombudet for forskning, Norsk samfunnsvitenskapelige datatjeneste. Innsamlede opplysninger vil bli anonymisert ved prosjektslutt 28.02.2023.*

**Meld din interesse i dag!**

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*Seksjon for idrettsmedisinske fag*

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*Tlf: 90 02 03 91*

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Brevet ble sendt til @@email
Ønsker du å melde deg av fremtidige utsendelser, klikk her.