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Validity of three commonly used activity monitors for estimating Sedentary time in school children

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Forord

Ideen til denne studien kom våren 2012 i samråd med Førsteamanuensis ved Universitet i Agder Sveinung Berntsen Stølevik, som ble veileder for denne oppgaven og som har finansiert studien. Jeg hadde tidligere forsøkt å få igang et prosjekt om fysisk aktivitet og barn. Det viste seg å være en åpning for et prosjekt som gikk ut på å sammenlikne forskjellige aktivitetsmålere hos barn, ble denne oppgaven født. Først gikk jeg gjennom bakgrunnslitteraturen i form av semesteoppgave våren 2012. Planlegging av selve utførelsen av studien begynte høsten 2012, noe som var omfattende og tidkrevende. Deltakere måtte rekruteres, aktivitetsmålere bestilles, aktivitetene måtte planlegges og pilot måtte gjennomføres. Universitetslektor ved Universitet i Agder Frøydis Nordgård Vik var biveileder for dette prosjektet. Hun fortjener en stor takk for hjelp med sine innspill og erfaring under hele prosessen. Dette var til spesielt stor hjelp i søken for å finne deltakere til studien og ved gjennomføring på selve testdagene. November 2012 ble studien utført ved Karuss skole i Vågsbygd, Kristiansand, den tok tre dager. En stor takk rettes mot Karuss skole for behjelpelighet og sammarbeid; stor takk til Forsker ved Norges Idrettshøgskole, Bjørge Herman Hansen for hjelp med prosjektets gjennomføring. Desember 2012 til mai 2013 ble brukt til analyser og skriving av oppgaven. Den som fortjener mest annerkjennelse for dette prosjektet er veileder Sveinung Berntsen Stølevik, for motivasjon, store bidrag til studien, tålmodighet til å svare på en million små og store spørsmål og konstruktiv veiledning under hele prosessen. Dette prosjektet har vært en enorm lærdom for meg, og en stor erfaring som ikke hadde vært mulig uten deg, så takk!

Av: Jarle Stålesen 13. Mai 2013

Sammendrag

Det er økende bevis for at stillesittende adferd er assosiert med fedme og at å begrense varighetene på den stillesittende adferden kan være et viktig budskap for å bedre kardio-metabolsk helse.

Hensikten med denne studien var å fastslå hvorvidt ActivPAL, ActiGraph GT3X+ (GT3X) og SenseWear Armband Pro3 (SWA) rapporterer forskjellig hvor mye tid barn bruker på stillesittende adferd, og om ActivPAL, som baserer seg på positur, gir et mer nøyaktig bilde på stillesittende adferd enn GT3X og SWA sammenlignet med observasjon og indirekte kalorimetri. Utvalget besto av 67 barn fra en lokal skole i Kristiansand, Norge. Deltakerne måtte være mellom 9 og 12 år gamle. Studien tok sted november 2012 og varte 3 dager. Barna deltok i sittende og ikke- sittende aktiviteter mens de hadde på seg alle tre aktivitetsmålere samtidig. Aktivitetsstasjonene var delt inn i undergrupper bestående av skjerm aktiviteter og lek- aktiviteter.

ActivPAL hadde signifikant forskjellig tid registrert som stillesittende ($P < 0.001$) i 4 ut av 6 aktivitetsstasjoner sammenliknet med GT3X og SWA. Når alle aktivitetsstasjoner var slått sammen viste at bare ActivPAL hadde signifikant ($P < 0.001$) forskjellig målinger sammenlignet med indirekte kalorimetri. ActivPAL registrerte tid mest forskjellig sammenlignet med de andre aktivitetsmålerne og indirekte kalorimetri, spesielt i aktivitetsstasjonene hvor barna sto oppreist. Denne studien konkluderer med at mer arbeid og testing er nødvendig før disse aktivitetsmålerne kan bli brukt til deskriptive studier hvor man måler tid brukt til stillesittende adferd blant barn.

Nøkkelord: Stillesittende adferd; Barn; Aktivitetssmålere; ActivPAL; SenseWear; ActiGraph

Summary

Increasing evidence that sedentary behavior is associated with obesity risk and that limiting bouts of sedentary behavior might be an important health message for supporting cardio metabolic health

The objectives were to determine whether ActivPAL, ActiGraph GT3X+ (GT3X) and SenseWear Armband Pro^3 (SWA) report sedentary time different in children, and if ActivPAL, which is based on posture, provide a more accurate tool for measuring sedentary time than GT3X and SWA compared to direct observation and indirect calorimetry. The sample consisted of 67 children from a local school in Kristiansand, Norway. Eligible participants were between the ages of 9-12 years. The present study was conducted over 3 days in November 2012. The children participated in sitting and non-sitting activities while wearing all three activity monitors simultaneously. Activity stations were divided into two sub groups; screen activities and play- like activities.

ActivPAL had significantly different measured time spent sedentary ($P < 0.001$) in four out of six activity stations compared to GT3X and SWA. All activity stations compared, only ActivPAL (P 0.001) were significantly different from indirect calorimetry. ActivPAL reported the most differently among the three monitors and was the most different compared to indirect calorimetry, especially different in the standing activities. The present study conclude that more work are needed before these monitors can be utilized in descriptive studies measuring sedentary time in children.

Keywords: Sedentary Behavior; Children; Activity monitors; ActivPAL; SenseWear; ActiGraph.

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1.0 Introduction

Sedentary behavior come from Latin, *sedere,* to sit, and means in context sitting during commuting, in the workplace, the domestic environment, and during leisure time. (1)

Increasing evidence supporting that sedentary behavior is associated with obesity risk.(2, 3) Independent of moderate- to vigorous physical activity, sedentary behavior has been reported to be inversely associated with high density lipoprotein (HDL) cholesterol of overweight and obese children; and implicates that limiting bouts of sedentary behavior might be an important health message for supporting cardio metabolic health, particular in relation to HDL cholesterol. (4) The suggestion that isometric contraction of antigravity muscles produce electromyographic and skeletal muscle lipoprotein lipase (LPL) change.(5, 6) Which suggest that standing should not be defines as sedentary behavior, inclinometers capturing time spent in different postures is therefore needed to further understand the health implications of sedentary behavior. Accelerometers are established in the field of measuring sedentary time. SenseWear Armband Pro_3 (SWA, Bodymedia), ActiGraph GT3X+ (GT3X, Pensacola, FL, USA) and ActivPAL™ (ActivPAL Technologies Ltd., Glasgow, UK) are monitors that has been used to measure sedentary time in the past. There are no studies to this date that we know of, comparing SWA with the ActivPAL or GT3X to measure sedentary time in children and there is not much literature for SWA independently. Validation of SWA in children when using indirect calorimetry, and including sedentary behavior and light physical activities has been carried out. (7-11) However, prior models and/ or older algorithms have been included and the activity bouts in the studies have often been treadmill based in laboratory settings. (7-11) GT3X have previously been applied as reference tool for intervention studies aiming to reduce sedentary behavior. (12, 13) Previously there has been studies comparing the validity of the GT3X against indirect calorimetry in children, but to our findings only to compare

various collection models, e.g. cut points available to GT3X. (14-16) ActivPAL has been applied as reference tool for intervention studies trying to change how much time was spent sedentary by the children in school.(17, 18) Validation of ActivPAL in children and adolescents have been positive thus far for monitoring sitting, standing and slow walking.(19-21) Some results; however, suggests limitation in capturing fast walking and running.(19) There are to our knowledge four comparative studies comparing GT3X and ActivPAL. (22-25) Both Ridgers et al. 2012 (24) and Martin et al. 2011 (22) found fair correlation between ActivPAL and GT3X, but both implicated that ActivPAL was more valid capturing sedentary behavior, especially sitting versus standing behavior. The objectives of the present study were to determine whether ActivPAL, GT3X and SWA report sedentary time different in children, and if ActivPAL, which is based on posture, provide a more accurate tool for measuring sedentary time than SWA and GT3X compared to direct observation and indirect calorimetry.

2.0 Theoretic Background

2.1 Defining Sedentary behavior

Sedentary behaviors are defined by most literature as any waking behavior characterized by an energy expenditure < 1.5 METs, which includes activities such as sitting and reclining. (16)

The focus on sedentary behavior has drastically increased the last decade, but the link between sitting and decease is not new. It began with epidemiologic studies in the 1950's which implicated that having work that involved sitting for prolonged periods of time, had a twofold increased risk of cardiovascular decease compared with jobs requiring physical activity and shorter bouts of sitting time. (26)

In health- related research we seek to understand the dose- response of a behavior, its physiological measures as blood pressure and triglycerides, its socio- demographic measures like income level and environmental factors such as number of televisions in a household relates to different health outcomes. (27) Defining sedentary behavior is not easy due to the uncertainties of the determining factors sedentary behavior has on health. By that I mean whether or not it is sitting still, performing activity of energy expenditure lower than 1.5 METs or too long bouts of sedentary behavior (or too few breaks) underlying the detrimental effects (5, 28, 29) sedentary behavior seems to have. These factors alone provide a basis for further research.

2.2Why register sedentary behavior

There is a broad agreement among clinicians, exercise scientists, and public health experts that moderate- to vigorous- intensity physical activity has a preventing role in cardiovascular decease, type 2 diabetes, obesity, and some types of cancer. (5) Research has been skewed against moderate- to vigorous physical activity. (5, 30) However, there is increasing evidence

that sedentary behaviors may be detrimental to health, independent of the physical activity level. (5, 28, 29)

The Australian Diabetes, Obesity and Lifestyle Study (AusDiab) collected data of screen time in more than 11,000 Australian adults. These adults were selected without known diabetes; however, television viewing time was positively associated with undiagnosed abnormal glucose metabolism. (31)

Lipoprotein lipase (LPL) is necessary for triglyceride uptake and high- density lipoprotein cholesterol production. (32) When sedentary, ~90-95% of the heparin- releasable LPL activity normally present in rat muscle with ambulatory activity were lost during hindlimb unloading, and thus seems to be dependent on local stimulation. (33) The rats was then put on a treadmill and after 4 hours walking, the LPL activity was raised ~8- folds ($P< 0.01$). (33) This sensitivity of muscle LPL to sedentary lifestyle and low- intensity contractile activity may explain why inactivity is a risk factor for metabolic diseases. Also why even non- vigorous activities as simple as just standing upright, provides marked protection against disorders involving poor lipid metabolism. (33) This might be explained by the isometric contraction of the antigravity- or postural muscles presented when standing still. (5) In the past, this form of standing would be labeled sedentary behavior, because of the limited amount of energy expenditure being used and the lack of body- movements. This also represents a problem of using accelerometers without inclinometers. This might suggest the need to equate "sedentary" with "sitting".

So it seems muscular unloading associated with prolonged sedentary time may have deleterious biological consequences, and the loss of local contractile stimulation induced through sitting could lead to both suppression of skeletal lipoprotein lipase (LPL) activity, and

reduced glucose uptake. (5, 32, 33) There is evidence supporting that the risk for obesity seems to increase in a dose response manner with increased time spent sedentary. (34)

Increasing sedentary behaviors happens because physical, economic, and social environments in which modern humans sit or move within, have been changing rapidly since the mid 20th century. (1) These changes in transportation, communications, workplace and domestic entertainment technologies have been associated with significantly reduced demands for physical activity and so increased time spent sedentary. (1) In today's western society opportunities for sedentary behavior are ubiquitous and are likely to increase with further innovations in technologies. (5) It might be time to consider excessive sitting as a serious health hazard, with the potential of giving consideration to the inclusion of less sedentary time or more breaks from sitting in physical activity- and health guidelines. (5) Children spend a large proportion of their day in sedentary behavior, and there is strong evidence that children spend more time in sedentary behaviors with increasing age. (35) When registering sedentary time in children prospective research have been reported to be insufficient, especially in adolescents, as most determinants have been studied only once. (36) These implications that sedentary behavior lack evidence, is supported by Chinapaw MJM, Proper KI (37) that found insufficient evidence for a relationship between sedentary time and body mass index and indicators of fat mass; and for a relationship between sedentary time and blood pressure, blood lipids and bone mass in their review of longitudinal studies. Moderate evidence was found for a significant inverse relationship between sedentary time and aerobic fitness. (37)

The factors showing the detrimental health effects associated with sedentary behavior, the increasing time spent sedentary and the lack of previous evidence present for children states the need for research on how to register sedentary time.

2.3 Methods for measuring/ registering sedentary behavior

When describing the various methods to measure sedentary behavior and light physical activity, it is important to understand what they are supposed to measure. Individuals is often described as sedentary, or in light-, moderate-, vigorous- or very vigorous physical activity; (38, 39) or simply as active or inactive. (40) These categories are used as determinants for finding associations between behavioral factors and other factors, e.g. associations between health related factors like diabetes type II or cardio metabolic risk and sedentary behavior or moderate- to vigorous activity. (2-4, 41-45)

The methods currently used to register sedentary time are accelerometers(12, 46-49), inclinometers(17, 18), monitoring screen time(50-54), self reports(55-57) and proxy reports(58). Methods used as criterion or reference methods when registering sedentary time in children are indirect calorimetry(14, 16, 21, 59) and direct observation(19, 20), accelerometers(56, 58), Inclinometers(17, 18), self reports(55). Doubly labeled Water method have previously been applied as criterion when trying to validate activity monitors in children, (60) but only gives total energy expenditure, so it does not provide intensity information. (61) This means that doubly labeled Water method can validate activity monitors in measuring total energy expenditure over a given time, but not to validate the monitors ability to register bouts of time spent sedentary. There has also been suggested that validation studies of light intensity and indoor activities could use room calorimeters, (61) but this severely restricts the types of activities that can be performed. I have found no studies applying Doubly labeled Water method and only one using room calorimetry (62) as criterion for methods registering sedentary time in children.

Methods used to register sedentary time in children

Among these devices, accelerometers are currently the most widely used sensors in human physical activity monitoring in clinical and free-living settings. (63) Accelerometers measure the frequency, duration and intensity of physical activities and habitual movements, by showing how quickly, often or far movement occurred compared to time, not by directly measuring how demanding the activities was. (63)

Accelerometers use counts per minute to categorize physical activity levels or sedentary behavior in categories, (24, 64) and to assess sedentary behavior and low- intensity movements accelerometers are considered the most practical and widely available units. (27)

The accelerometer- based approach provides a big challenge in that the accelerometer- "counts" is inherently neither meaningful nor interpretable. (65) The raw- data needs to be converted into a quantitative estimate of caloric expenditure or the related categorical measure of time spent in sedentary-, light-, and moderate- or vigorous- intensity activity to be interpretable or meaningful. (65)

Inclinometers use static gravitational force to determine orientation that can be used for detecting sedentary behaviors such as sitting time, (66) and is a relatively new method to classify behaviors as how it is conducted, not how physical demanding it is. (64) If it can be applied to a population wide range, it can give many answers about sedentary behavior and health markers. (67) When validating, the inclinometers has an advantage in that it can be validated against direct observation. (19) Although very time consuming, direct observation serve as a very good criterion for inclinometer given that it register actual human behavior and hold great advantages in that it is very cost efficient compared to e.g. indirect calorimetry. (68)

Self-report is a tool for measuring sedentary behavior, and include diaries, questionnaires and proxy reports i.e. parental report of children's activity. (69) Self- reports are commonly used in epidemiological research because they are relatively simple to administer, fairly inexpensive and have the ability to provide information on the type of context of physical activity in a large sample of individuals. (68)

There are many previous studies using self reports(50, 52, 53, 70) and parent reports(50, 51, 71-76) focusing on reducing sedentary behavior in children. But self- report methods have considerable limitations, especially when measuring physical activity or sedentary behaviors with children. (69) These limitations include item interpretation, recalling the intensity, frequencies and duration of bouts of activity or inactivity, the lack of objectivity of the instruments and social desirability effects. (68, 69, 77)

Such limitations are particularly present when dealing with children since the majority of children's activity is sporadic in nature, and have short duration, it could prove difficult or impossible for them to recall. (69) Also children often overestimate the amount of time engaged in physical activity, as well as the intensity of their physical activity participation. (78) This does probably transfer to children's recollection of sedentary bouts and overall sedentary time.

Intervention studies reducing television viewing and computer use to reduce sedentary time in children are for example used to reduce obesity. (54) Interventions applying this method to reduce sedentary time by limiting screen time often use this strategy in addition to behavioral modification strategies. (50-53) When studying the method it is clear that a great limitation of this types of method is that it says nothing about intensity, bouts of "sedentaryness", or any other activity other than the amount of screen time. It can perhaps be applied as a descriptive

method for sedentary time in large populations, but it gives few answers about the determinants of sedentary behavior.

There has been studies applying pulse from heart rate monitors to establish cut points for lying, sitting, standing, walking or very active in children. (79-81) So it is plausible it might have been applied to register sedentary time in children in the past, but after an extensive search in various databases (MedLINE; PubMed, Cochrane library, SPORT Discus, Google Scholar) there are yet to be found any studies actually using heart rate monitor when registering sedentary time in children.

Methods used as criterion method for monitors registering sedentary time in children

Registering sedentary time using wearable monitors like accelerometers is grounded in the measurement of energy expenditure, and are calibrated and validated against energy expenditure measurements made by calorimetry. (82)

Calorimetry uses metabolic equivalent (MET) with multiples of predicted- or measured resting metabolic rate (RMR) or basal metabolic rate (BMR). (14, 61, 82) MET is often defined as the quantity of oxygen consumed by the body from inspired air under basal conditions and is equal on average to 3.5 ml oxygen/kg per min. (83)

The rate of energy expenditure has been utilized to categorize physical activities, and there has been made coding scheme for a vast amount of physical activities, which was developed to enhance the comparability of results across studies using self- reports of physical activity. (84)

It has been implicated that the use of the 1- MET value of 3.5 ml $O_2 \cdot kg^{-1} \cdot min^{-1}$ and 1 kcal $\cdot kg^{-1} \cdot h^{-1}$ does not equate measured resting VO_2. (85) There is compelling evidence that resting metabolic rate decreased with increasing body mass index (BMI), and increase with age and

that the established MET- values overestimate energy expenditure (85-87). When registering time spent sedentary, this implies that the subjects that are being sedentary, might be classified as active. (85)

Indirect calorimetry measures respiratory gas exchange (oxygen uptake and carbon dioxide production) to allow calculation of energy expenditure and are an appropriate criterion for minute-by-minute energy expenditure. (61) According to Bassett, Rowlands (61) validation studies should use methods such as indirect calorimetry, and many validation studies has used it as criterion. (14, 16, 21, 59)

Direct observation is a method which a trained observer classifies free-living physical activity by objectively recording the activity behavior for a predetermined length of time. (68) When using direct observation it typically occurs in natural settings such as at home or during school. (68) Direct observation is an objective method that provides contextually rich data to identify other factors related to physical activity behavior, e.g. physical and social factors, can provide information on the type and intensity of physical activity; and also applies to a variety of different settings. (68) The biggest disadvantage by direct observation is the time-intensive nature of observer training and data coding. (68)

Accelerometers, Inclinometers and self reports are tools that has been used as criterions in intervention studies. (17, 18, 55, 56, 58) These studies have in one way or another registered sedentary time in children, and although criterion measure, they have been adequately described in the paragraph describing methods used to register sedentary time in children and in the present study; to imply that great caution should be taken if chosen as criterion measure.

3.0 Methods and method criticism

3.1 Methods

Study design

The present study was conducted over 3 days in November 2012. The children participated in sitting and non-sitting activities while wearing all three activity monitors simultaneously. As criterion, a sub sample also wore a portable oxygen analyzer and one test leader observed each group of children while they performed the various activities. The direct observation was used to control that the children performed the activities as planned Activity stations were divided into two sub groups; screen activities and play- like activities. Each activity station lasted for 6 minutes and was completed in a randomized order. Written informed consent to take part was obtained from the participating children and their parents. The regional committee for medical and health research ethics; southeast was informed about the study and had no objections.

Subjects

In the present study, 35 boys and 32 girls were recruited from the 5^{th}, 6^{th}, and 7^{th} grade of a local school in Kristiansand, Norway. Eligible participants were between the ages of 9-12 yrs and able to wear a facemask for oxygen consumption measurements for the duration of one hour.

Procedures

The test location was a classroom at the local school. In order to measure a wide range of light physical activities and sedentary behaviors, six different games or exercises were carried out. These included sitting and standing with arm movement, walking regularly, sitting down, and standing up again, sitting idle watching television, sedentary gaming and standing up playing movement based videogames. Each morning the test personnel synchronized their watches

according the computer clocks. The children performed the assigned activity for 6 minutes on each activity station. Each child was weighed to the nearest 0.1kg using a body- mass monitor (Seca opima, Hamburg, Germany) and age was collected.

SWA is a wireless, multi sensor, activity monitor that weighs 79 grams and are worn on the triceps muscle on the upper right arm. The SWA has been described more thoroughly in previous validation studies. (60, 88) The MET values used for SWA in the present study were sedentary 1-1.49 MET's and 1.5< as other activities. The SenseWear Professional 6.1 software was used for analyzing the raw data.

GT3X is a tri- axial accelerometer that weighs 19g, measuring 46mm x 33mm x 15mm and has a battery life expectancy of 30 days. It has a sample rate of 30 – 100 herz in 10 Hz increments. Since 2012, there has been three studies looking to validate and comprehensively described GT3X. (14, 16, 23) The GT3X monitor was initialized in 100Hz and 15 seconds epochs and was worn on the right side of the hip. When analyzing the raw data the test group used counts per minute (CPM) on the vertical axis using the youth specific ActiGraph cut points of Evenson et al.(59). For the analysis, the ActiLife 5 software was used.

The ActivPAL physical activity logger is a small, single-unit, lightweight physical activity monitor that can record posture and activity during a 7-day period. ActivPAL has previously been tried validated and have thoroughly been described. (19-21) The ActivPAL monitor was attached to the anterior side of the right thigh using a hydrogel pad, which adheres the ActivPAL directly to the subjects thigh, named PAL*stickie*™. Time registered as sitting down or standing still was categorized as sedentary time, while stepping time was categorized as other activities. ActivPAL™ process and presentation v6.5.1 Research Edition was used for analyzing.

ActivPAL and GT3X were initialized, and then attached to the child along with SWA. Oxygen consumption was measured using the valid portable gas analyzers METAMAX II (MMXII) and METAMAX 3X (MMX3) (CORTEX Biophysik GmbH, Leipzig, Germany)(89). MMXII was used through all stations, while MMX3 was stationary at the screen-based activities. Before each test MMXII were initialized and calibrated according to the manufacturers instruction and strapped to the subject, while MMX3 was initialized and calibrated before testing commenced the present day. For each child an appropriate facemask was chosen and fitted to ensure air did not leak. When analyzing the data from MMXII, MetaSoft® version 1.2 software was used, MMX3 the MetaSoft® version 3.9.8 software was used. MET values for MMXII and MMX3 was calculated using the predictive basal metabolic rates for children (1 MET= BMR ml/kg/min). We calculated basal metabolic rate using the formula made by FAO/WHO/UNU (1985)(90); 0.0732*weight*2.72 for boys, and 0.0510*weight*3.12 for girls.

Station 1: Standing ball- toss

The children stood upright in the same spot for the duration of the test and threw a rubber ball back and forth over a distance of approximately 2.5 meters. To ensure that the children were focused and motivated, the test group motivated the children by creating a small competition of who could throw it continuous without dropping the rubber ball on the floor.

Station 2: sitting ball- toss

The children performed this exercise in a seated position and threw a rubber ball over a distance of approximately 2 meters. The distance was sometimes adjusted due to the variations of arm strength among the children. The goal of the exercise was to complete as many successful throws in a row without dropping the ball on the floor; the test group

motivated the children by creating a small competition of who could throw it consequently without dropping the rubber ball on the floor.

Station 3: Musical chairs

To make the children do this kind of assignment the test group prepared a round table (approximately 1.5 meter in diameter) with adequate space for two persons to walk around it. Then added one chair, made the children walk in circles around the table, at a low pace with a fixed distance between. After some time the test leader would notify them that the first of the children to sit down would receive a point.

Station 4: Television viewing (TV)

The children sat down in their chairs and watched television. They could not stand up or move the chair.

Station 5: Sedentary gaming

The children were seated in front of a television with a PlayStation 3 Wireless Dual Shock 3 Hand controller™. The children played a driving simulator game named: NASCAR 2011 The Game™. The setup was a single race, split screen, against each other on a pre-selected course.

Station 6: Gaming move

The children were standing upright in front of a television, each holding a PlayStation Move Hand Controller™ (one controller per child). The children played a swordfight simulator named Gladiator in the PlayStation move game Sports Champions™, published by Sony Computer Entertainment. The exercise used split screen and two people could fight each other using the PlayStation Move controller as a sword. The PlayStation Eye™ captured the light

from the PlayStation Move controller being held by the child and was projected to the avatar on the screen.

Statistical analysis

The middle 4 minutes of the tests were used for analyzing, while the first and last minute were excluded. Descriptive data are presented as median with 95% confidence intervals and results as significant difference below $P < 0.05$. Data were checked for normality, and non-parametric analysis was chosen. Related- samples Friedman's Two-Way analysis of variance by ranks was used to find significantly differences between the monitors and compared to the criterion estimates from IC. Level of significance was set to 0.05. Analyses were conducted in SPSS® (Statistical Package for Social Sciences, Version 19 for Windows. SPSS Inc. Chicago, USA).

3.2 Method critique

Three different activity monitors were compared in the present study, ActivPAL, ActiGraph GT3X+ and SenseWear Armband Pro 3. When cross validating different methods, it is important to transform the raw data from each device into interpretable quantifiable data that can be compared on the same level. In the present study, ActivPAL had raw output as time spent in different postures. ActiGraph had raw data as counts per minute, and SWA produced raw output based on counts from its two axis and heat related sensors like heat flux, skin temperature, near body ambient temperature and galvanic skin response.

SWA uses algorithms to calculate average Metabolic Equivalents per 60 seconds dependent on the subjects age, sex, height, weight, handedness, and if the subject smokes. The raw data from the activity monitors are not comparable at this level, so it has to be decided how to transform the different data to one interpretable output. The type of output are often decided by the objective of the study, e.g. in the present study we chose time spent sedentary versus other activities. How to interpret the raw data from the activity monitors are often easier than to figure out how to transform the raw data into one interpretable output so that the monitors can be compared. To define the raw data output for ActivPAL we defined sitting/lying and standing as sedentary while stepping was defined as other activities.

GT3X produce counts per minute and gives the researcher the freedom to choose how to interpret these. There are many validated cut points for children, however the cut points from Evenson (59) and Treuth (91) have been found to be the most accurate when measuring sedentary behavior in children. (24) These seemed to capture sedentary time pretty similar, results implicate that Treuth (91) had lower specificity and sensitivity when measuring time spent moderate- to vigorous active and vigorously active, (92) therefore we chose the cut points from Evenson (59). The various cut points for GT3X may impact the results, according to ActiGraph homepage (93) the software mainly use 9 different cut points, aimed at infants

(less than 1 year old), toddlers (ages between 1 and 2), Pre- school children (3 to 5 years old), children (6 to 18 years old) and Adults (19 < years old).

SWA outputs was registered as sedentary time for MET values of 1.00 - 1.49 MET's and other activities as 1.50 < METs. For MMX we used the same cut points of 1.00 - 1.49 MET's; however, the equation to transform L/min to MET's, needs either resting metabolic rate, basal metabolic rate or the use of the standardized 3.5 ml/kg/min of MET's. In the present study we calculated basal metabolic rate using the formula made by FAO/WHO/UNU (1985) (90); 0.0732*weight*2.72 for boys, and 0.0510*weight*3.12 for girls. These numbers are predicted, so in itself there is uncertainty applying these methods, other studies have found that the equations from FAO/WHO/UNU (1985) (90) overestimate basal metabolic rate (94, 95) especially for sedentary individuals (94). None of these studies has tested the equation for basal metabolic rate in children which is a limitation of using this method in the present study. This could explain high levels of measured activity in the TV- watching station and when sedentary gaming by MMX.

When establishing a reference or criterion in this study, the reference method had to be considered more precise then activity monitors the study aimed to validate. Indirect calorimetry was used, and are considered an appropriate criterion for minute-by-minute energy expenditure. (61) Direct observation was also used to evaluate the inclinometer, intensity level and how the activity was performed, like which posture the child was in and how active the children were across the different activities. It was important that the reference method measure sedentary behavior on the same level as the activity monitors compared. The bias attached to using this reference method, e.g. MMX and the prediction of basal metabolic rate, needed to be independent of the bias present at the activity monitor we validated, e.g. unable to capture movement that is not in the hips as GT3X, which is located on the hip. Validation studies should ideally have two reference methods. In the present study we had

indirect calorimetry and direct observation as reference, so in theory we had two reference methods. Direct observation was used mostly as a criterion for the inclinometer and to control how the various activities were executed, and so direct observation cannot give quantifiable data as how metabolic strenuous it was for the individuals, as indirect calorimetry can.

The reference method should not affect how the children acted during testing. The toll of wearing a tightly fastened face- mask, and all the gear accompanying the MMX and also the presence of adults observing had to affect the performance.

The activity stations were designed to capture screen time, sedentary gaming, playing videogames with movement controllers and play- like activities. In several validation studies walking or running on a treadmill has been used, (9, 10, 21, 25, 62, 96) therefore it was important to test activities closer to free living. If this was a descriptive study of sedentary behavior in free living, the fact that the activity stations were controlled would be a weakness. However this was a validation study and although the children were told what to do, the children were also encouraged to complete the activity stations as they wanted themself, which is a strength in this study since validation studies often are very rigorous in their execution. (9, 96)

The activity stations were thoroughly planned and thought through, but still based upon the test leaders and planners considered opinion of what types of activities are relevant to compare activity monitors when registering sedentary time. To strengthen the validity of the study, post validation of the activity stations could be done to standardize the tests. The interunit variability could have been tested in all the activity monitors before testing started. Post study, ActivPAL was tested for functionality and confirmed functioning as they should, using tests provided by the manufacturer. The tests should also have been performed twice on different occasions to test the reproducibility. During testing there were large differences in

behavior between the children. While some sat completely still when watching television and during sedentary gaming, others almost could not sit still for a second, causing these stations to have the highest individual variation. These individual variations were especially present for sedentary gaming and TV- watching are shown as wider range in the 95% confidence intervals across all monitors.

When using activity monitors and reference methods relying on computers, calibration, initialization and downloading, there has to be considered the occurrence of technical errors, and it is therefore important to consider this when choosing how large sample a study needs. Fortunately, the sample in the present study was large enough for the activity monitors to bear these dropouts. The few MMX data this study collected and adding technical errors when downloading the raw data, the sample for MMX became very low in the end, and harmed the study's aim of using indirect calorimetry as reference method. The study could have increased validity by performing follow-up MMX measurements post testing. The sample was not screened for height, weight, ethnicity, socioeconomic status, previous deceases, asthma, or any other factor beside that the child had to be in 5^{th}, 6^{th} or 7^{th} grade and be physically able to perform the various activities and be able to where a face-mask. So it is debatable whether our sample was representative on a national scale or international scale. As more research accumulate geographically differences and other factors that may impact the performance and results of the activity monitors should be looked into to determine the impacts they might have.

The activity monitors were non- invasive and instruction about the activity stations were explained beforehand, so how children move during testing should be relatively the same.

The researchers/ test-leaders also have the capability to affect the results in validation studies. It was therefore important that we guided the children, instead of constantly correcting their

behavior as we might prefer. During testing there were three test-leaders present, one handling the technical aspects of mounting- and unmounting the activity monitors and MMX, calibration and initializations etc. Two test-leaders handled the activity stations and took precise time of each individual and observed what the children did. This went smooth, but one extra person helping with both the technical aspect and at managing the activity stations would have helped a great deal, and could have contributed to more MMX measurements.

To conclude, the test design was not flawless, and the low count of completed indirect calorimetry measurements lowered the power of the present study. However the study had several strengths like the application of more relatable activities for children when testing activity monitors; and exciting new results implicating that more research is needed before using objectively wearable monitors to register sedentary time in children, especially for inclinometers. In such a matter does this study contribute to the field of registering sedentary time in children.

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Validity of three commonly used activity monitors for estimating Sedentary time in school children

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Title for running head: Testing of activity monitors in children

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ABSTRACT

Purpose: Sedentary behaviors, defined as sitting and lying down and activities of low levels of energy expenditure, is gaining more attention regarding health aspects. It is important to focus on the health aspect and prevention of extensive sedentary behaviors in children. The major challenge today is to find a cost-affordable way to register sedentary time in which both are applicable and valid.

The objectives of the present study were to determine whether ActivPAL, ActiGraph GT3X+ (GT3X) and SenseWear Armband Pro^3 (SWA) report sedentary time different in children, and if ActivPAL, which is based on posture, provide a more accurate tool for measuring sedentary time than SWA and GT3X compared to direct observation and indirect calorimetry.

Method: The sample consisted of 67 children from a local school in Kristiansand, Norway. Eligible participants were between the ages of 9-12 years. The present study was conducted over 3 days in November 2012. The children participated in sitting and non-sitting activities while wearing all three activity monitors simultaneously. Activity stations were divided into two sub groups; screen activities and play- like activities.

Results: ActivPAL had significantly different measured time spent sedentary ($P < 0.001$) in four out of six activity stations compared to GT3X and SWA. All activity stations compared, only ActivPAL (P 0.001) were significantly different from indirect calorimetry. ActivPAL reported the most differently among the three monitors and was the most different compared to indirect calorimetry, especially different in the standing activities. The present study

Conclusion: More work are needed before these monitors can be utilized in descriptive studies measuring sedentary time in children.

Keywords: Indirect calorimetry. ActivPAL. SenseWear. ActiGraph.

INTRODUCTION

Paragraph Number 1 Sedentary behavior come from Latin, *sedere,* to sit, and means in context sitting during commuting, in the workplace, the domestic environment, and during leisure time. (1)

Increasing evidence supporting that sedentary behavior is associated with obesity risk.(2, 3) Independent of moderate- to vigorous physical activity, sedentary behavior has been reported to be inversely associated with high density lipoprotein (HDL) cholesterol of overweight and obese children; and implicates that limiting bouts of sedentary behavior might be an important health message for supporting cardio metabolic health, particular in relation to HDL cholesterol.(4) The suggestion that isometric contraction of antigravity muscles produce electromyographic and skeletal muscle lipoprotein lipase (LPL) change.(5, 6) Which suggest that standing should not be defines as sedentary behavior, inclinometers capturing time spent in different postures is therefore needed to further understand the health implications of sedentary behavior and seated/ lying- versus standing activities.

Paragraph Number 2 Accelerometers are established in the field of measuring sedentary time. SenseWear Armband Pro_3 (SWA, Bodymedia), ActiGraph GT3X+ (GT3X, Pensacola, FL, USA) and ActivPAL™ (ActivPAL Technologies Ltd., Glasgow, UK) are monitors that has been used to measure sedentary time in the past. There are no studies to this date that we know of, comparing SWA with the ActivPAL or GT3X to measure sedentary time in children and there is not much literature for SWA independently. Validation of SWA in children when using indirect calorimetry, and including sedentary behavior and light physical activities has been carried out (7-11). However, prior models and/ or older algorithms have been included and the activity bouts in the studies have often been treadmill based in laboratory settings.(7-11) GT3X have previously been applied as reference tool for intervention studies aiming to reduce sedentary behavior.(12, 13) Previously there has been studies comparing the validity

of the GT3X against indirect calorimetry in children, but to our findings only to compare various collection models, e.g. cut points available to GT3X.(14-16). ActivPAL has been applied as reference tool for intervention studies trying to change how much time the children in school spent sedentary.(17, 18) Validation of ActivPAL in children and adolescents have been positive thus far for monitoring sitting, standing and slow walking.(19-21) Some results; however, suggests limitation in capturing fast walking and running.(19) There are to our knowledge 4 comparative studies comparing GT3X and ActivPAL.(22-25) Both Ridgers et al. 2012 (24) and Martin et al. 2011 (22) found fair correlation between ActivPAL and GT3X, but both implicated that ActivPAL was more valid capturing sedentary behavior, especially sitting versus standing behavior. The objectives of the present study were to determine whether ActivPAL, GT3X and SWA report sedentary time different in children, and if ActivPAL, which is based on posture, provide a more accurate tool for measuring sedentary time than SWA and GT3X compared to direct observation and indirect calorimetry.

MATERIAL AND METHODS

Study design

Paragraph Number 3 The present study was conducted over 3 days in November 2012. The children participated in sitting and non-sitting activities while wearing all three activity monitors simultaneously. As criterion, a sub sample also wore a portable oxygen analyzer and one test leader observed each group of children while they performed the various activities. The direct observation was used to control that the children performed the activities as planned Activity stations were divided into two sub groups; screen activities and play- like activities. Each activity station lasted for 6 minutes and was completed in a randomized order. Written informed consent to take part was obtained from the participating children and their parents. The regional committee for medical and health research ethics; southeast was informed about the study and had no objections.

Subjects

Paragraph Number 4 In the present study, 35 boys and 32 girls were recruited from the 5th, 6th, and 7th grade of a local school in Kristiansand, Norway. Eligible participants were between the ages of 9-12 yrs and able to wear a facemask for oxygen consumption measurements for the duration of one hour.

Procedures

Paragraph Number 5 The test location was a classroom at the local school. In order to measure a wide range of light physical activities and sedentary behaviors, six different games or exercises were carried out. These included sitting and standing with arm movement, walking regularly, sitting down, and standing up again, sitting idle watching television, sedentary gaming and standing up playing movement based videogames. Each morning the test personnel synchronized their watches according the computer clocks. The children performed the assigned activity for 6 minutes on each activity station. Each child was weighed to the nearest 0.1kg using a body- mass monitor (Seca opima, Hamburg, Germany) and age was collected.

Paragraph Number 6 SWA is a wireless, multi sensor, activity monitor that weighs 79 grams and are worn on the triceps muscle on the upper right arm. The SWA has been described more thoroughly in previous validation studies. (60, 88) The MET values used for SWA in the present study were sedentary 1-1.49 MET's and 1.5< as other activities. The SenseWear Professional 6.1 software was used for analyzing the raw data.

Paragraph Number 7 GT3X is a tri- axial accelerometer that weighs 19g, measuring 46mm x 33mm x 15mm and has a battery life expectancy of 30 days. It has a sample rate of 30 – 100 herz in 10 Hz increments. Since 2012, there has been three studies looking to validate and comprehensively described GT3X. (14, 16, 23) The GT3X monitor was initialized in 100Hz and 15 seconds epochs and was worn on the right side of the hip. When analyzing the raw

data the test group used counts per minute (CPM) on the vertical axis using the youth specific ActiGraph cut points of Evenson et al.(59). For the analysis, the ActiLife 5 software was used.

Paragraph Number 8 The ActivPAL physical activity logger is a small, single-unit, lightweight physical activity monitor that can record posture and activity during a 7-day period. ActivPAL has previously been tried validated and have thoroughly been described. (19-21) The ActivPAL monitor was attached to the anterior side of the right thigh using a hydrogel pad, which adheres the ActivPAL directly to the subjects thigh, named PAL*stickie*™. Time registered as sitting down or standing still was categorized as sedentary time, while stepping time was categorized as other activities. ActivPAL™ process and presentation v6.5.1 Research Edition was used for analyzing.

Paragraph Number 9 ActivPAL and GT3X were initialized, and then attached to the child along with SWA. Oxygen consumption was measured using the valid portable gas analyzers METAMAX II (MMXII) and METAMAX 3X (MMX3) (CORTEX Biophysik GmbH, Leipzig, Germany)(89). MMXII was used through all stations, while MMX3 was stationary at the screen-based activities. Before each test MMXII were initialized and calibrated according to the manufacturer's instructions and strapped to the subject, while MMX3 was initialized and calibrated before testing commenced the present day. For each child an appropriate facemask was chosen and fitted to ensure air did not leak. For analyzing the data from MMXII, MetaSoft® version 1.2 software was used, For MMX3 the MetaSoft® version 3.9.8 software was used. MET values for MMXII and MMX3 was calculated using the predictive basal metabolic rates for children (1 MET= BMR ml/kg/min). We calculated basal metabolic rate using the formula made by FAO/WHO/UNU (1985)(90); 0.0732*weight*2.72 for boys, and 0.0510*weight*3.12 for girls.

Paragraph Number 10 Station 1: Standing ball- toss

The children stood upright in the same spot for the duration of the test and threw a rubber ball back and forth over a distance of approximately 2.5 meters. To ensure that the children were focused and motivated the test group motivated the children by creating a small competition of who could throw it continuous without dropping the rubber ball to the floor.

Paragraph Number 11 Station 2: sitting ball- toss

The children performed this exercise in a seated position and threw a rubber ball over a distance of approximately 2 meters. The distance was sometimes adjusted due to the variations of arm strength among the population. The goal of the exercise was to complete as many successful throws in a row without dropping the ball on the floor; the test group motivated the children by creating a small competition of who could throw it consequently without dropping the rubber ball to the floor.

Paragraph Number 12 Station 3: Musical chairs

To make the children do this kind of behavior the test group prepared a round table (approximately 1.5 meter in diameter) with adequate space for two persons to walk around it. Then added one chair, made the children walk in circles around the table, at a low pace with a fixed distance between. After some time the test leader would notify them that the first of the children to sit down would receive a point.

Paragraph Number 13 Station 4: Television viewing (TV)

The children sat down on each chair and watched television. They could not stand up or move the chair.

Paragraph Number 14 Station 5: Sedentary gaming

The children were seated in front of a television with each PlayStation 3 Wireless Dual Shock 3 Hand controller™. The children played a driving simulator game named: NASCAR 2011 The Game™. The setup was a single race, split screen, against each other on a pre-selected course.

Paragraph Number 15 Station 6: Gaming move

The children were standing upright in front of a television, each holding a PlayStation Move Hand Controller™ (one controller per child). The children played a swordfight simulator named Gladiator in the PlayStation move game Sports Champions™, published by Sony Computer Entertainment. The exercise used split screen and two people could fight each other using the PlayStation Move controller as a sword. The PlayStation Eye™ captured the light from the PlayStation Move controller being held by the child and was projected to the avatar on the screen.

Statistical analysis

Paragraph Number 16 The middle 4 minutes of the tests were used for analyzing, while the first and last minute were excluded. Descriptive data are presented as median with 95% confidence intervals and results as significant difference below $P < 0.05$. Data were checked for normality, and non- parametric analysis was chosen. Related- samples Friedman's Two-Way analysis of variance by ranks was used to find significantly differences between the monitors and compared to the criterion estimates from IC. Level of significance was set to 0.05. Analyses were conducted in SPSS® (Statistical Package for Social Sciences, Version 19 for Windows. SPSS Inc. Chicago, USA).

RESULTS

Paragraph Number 17 The total sample consisted of 66 children (34 boys; 10.9 ± 0.8 years). Technical failure to download raw data with GT3X resulted in the exclusion of five children. Another four children were excluded from further analysis due to technical error to download the ActivPAL raw data and three children were excluded for the SWA for the same reason as for GT3X and ActivPAL. The analysis sample included 54 children (27 boys 11.1 ± 0.7 years) with a mean weight of 41.9 ± 9.6 kg.

Paragraph Number 18 Table 1 shows registered sedentary time spent in each activity station for the three monitors. ActivPAL had significantly different measured time spent sedentary ($P < 0.001$) in four out of six activity stations compared to both SWA and GT3X. There was no significantly different measured sedentary time by SWA compared to GT3X, with the exception of the seated ball- toss activity station ($P= 0.018$).

Paragraph Number 19 Median difference between the activity monitors when combining all activities based on seated or standing activity are summarized in figure 1. When comparing standing and seated activities, there were significant differences between all three monitors when seated (SWA vs. GT3X= P 0.028; SWA vs. ActivPAL= P <0.001; GT3X vs. ActivPAL = P 0.003). When standing only ActivPAL had significantly ($P < 0.001$) different results compared to the other monitors. When the children were standing upright and walking, ActivPAL reported that children were seated or standing still on average 9.3 (± 1.9) minutes out of 12 minutes in total.

Paragraph Number 20 Median minutes spent sedentary in the various activities the sub sample that wore an oxygen analyzer performed is summarized in table 2. Compared to indirect calorimetry ActivPAL was significantly different in four out of six stations (Sitting ball toss= P 0.020; Television viewing= P 0.001; Sedentary gaming= P 0.004; Gaming move= $P < 0.001$).

Paragraph Number 21 The sample that completed all activity stations wearing both the activity monitors and oxygen analyzer is compared in figure 2. The different activity stations were summarized as standing- or seated activities and all activity stations in was grouped together as one total. Median minutes spent sedentary were significantly higher for ActivPAL compared to indirect calorimetry in all groups compared (Seated activities= P 0.002; Standing activities= P 0.013; All stations combined= P 0.001). There were no significant difference comparing indirect calorimetry to either SWA or GT3X when stations grouped together in seated, standing or all combined.

DISCUSSION

Paragraph Number 22 In the present study, we found that activity monitors drastically differ in their reports of sedentary time. ActivPAL seemed to underestimate sedentary time. In activities like musical chairs where the children walked for most part of the time, confirmed by direct observation, ActivPAL reported sedentary time over half of the time and seemed to do so during all standing activities, clearly overestimating sedentary time.

Paragraph Number 23 Our findings contradicts previous research reporting that ActivPAL with its inclinometer is a valid tool for measuring sedentary time compared to direct observation (19, 20, 23, 25) and IC (21). Compared to direct observation ActivPAL was sometimes good at detecting posture, in Ball toss seated (correct 75% of time), Television viewing (correct 92% of the time) and Sedentary gaming (correct 83% of the time). However, grave mismatch was present in Ball toss standing (mismatch 92% of the time) and Musical chairs (mismatch 99% of the time). For Gaming move, it's hard to classify since some children stood still and more or less were sedentary, while other children jumped around being very active. A previous study had substantial mismatch (20) in a small number of individuals when measuring time spent sedentary using ActivPAL. Although they did not

publish how many mismatches there were, it implicates that, at least on an individual level, ActivPAL is capable of sizeable bias.

Paragraph Number 24 For registering sedentary time in children, more studies on SWA is needed. As most studies have been done using previous models and/ or older algorithms in a laboratory setting, (7-11) it clearly emphasize the need for validation and comparison of SWA. Both in free living settings and in situations more applicable to actual activities performed by children. Validation and comparison of SWA is especially important before applying it in more intervention studies registering sedentary time in children.

Paragraph Number 25 Further analysis on GT3X in children in various situations and contexts compared to other monitors in the field of registering sedentary time in children is important to establish which of the present cut points for children has the highest precision. In addition, to find out whether the cut points available needs further adjustments and fine-tuning.

Paragraph Number 26 There has been significant difference between ActivPAL and GT3X in measuring sedentary time in children in the past, (22) but only 4.3% difference. As earlier stated, we found no earlier studies trying to compare this version of SWA with GT3X and ActivPAL. Compared to IC, the GT3X and SWA performed adequately, with the exception of television watching and sedentary gaming. These differences may be explained by the child's nature of behavior.

Paragraph Number 27 In our study, when the children were supposed to sit still, they were constantly moving their upper body, kicking with their legs and small rapid posture changes occurred frequently. This may have given a higher VO_2 score, while for the accelerometer, the movement might be too small, insignificant or the movement type is not local to where the

accelerometer is positioned to register. Our findings emphasize the need for more comparative studies among activity monitors aiming at registering sedentary time in children.

Paragraph Number 28 Strength of the present study was the application of multiple monitors used to register time spent sedentary. The activities conducted in the present study were more associated to the kind of activities children perform in free living. The activities included play- like activities present in physical education in school and similar to games children play in outside environments. The present study included typical sedentary behaviors such as watching television and sedentary gaming. Playing video games dependent on movement was included to compare how much time the activity monitors registered as sedentary time compare to sedentary gaming and play like activities. While sedentary gaming was mostly classified as sedentary, playing videogames dependent on movement scored about the same as standing still throwing a ball and Musical chairs. More research should be made on whether or not playing videogames dependent on movement is an adequate substitute for sedentary gaming in decreasing sedentary time in children, but our results are positive. The use of observation to control what the children did and how they performed the activity strengthen the study. It applies well as a good criterion when validating inclinometers, especially when the activity types are fixed and organized in a station- like manner as in the present study. To further strengthen the use of direct observation, video recording could have been applied. Limitations of the present study were the low sample of indirect calorimetry measurements, which made direct observation our primary criterion, and the use of predictive basal metabolic rate instead of measuring the resting metabolic rate of the children beforehand.

Paragraph Number 29 Future directions based on this study should be that accelerometers and inclinometers should not yet be applied as reference tools in interventional studies, and more research on the various activity monitors used to register sedentary time in children

should be done. More research comparing accelerometers and inclinometers is an important field in determining how sedentary time and behaviors will be registered in the future. Also future research in activity types as potential substitutes for sedentary behaviors, e.g. sedentary gaming versus playing videogames dependent on movement, should be undertaken to try decreasing sedentary time in children.

CONCLUSION

Paragraph Number 30 The three monitors compared in the present study reported different sedentary time in children. ActivPAL was the monitor reported most differently among the three monitors in the present study and was the most different compared to indirect calorimetry. ActivPAL reported in the standing activities, particularly different sedentary time compared to the other monitors and indirect calorimetry. ActivPAL use posture to register sitting time, and is both exciting and needed type of activity monitor for registering sedentary time, however it needs more research before the inclinometer can be used to register sedentary time in children. This study conclude that more work are needed before these monitors can be utilized in descriptive studies measuring sedentary time in children.

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Attachments

Attachment 1: Tables and figures

Attachment 2: Information provided about the testing given to the school and research-assistants, in Norwegian

Attachment 3: Consent form that was sent home with the children, and needed to be signed in order to participate in the present study, in Norwegian

TABLES AND FIGURES

Table 1. Median of minutes spent sedentary and 95% confidence intervals for SWA, GT3X and ActivPAL (APAL) among the children across the individual activity stations, lasting 4 minutes in total.

Table 2. Median of minutes spent sedentary and 95% confidence intervals for SWA, GT3X, and ActivPAL (APAL) compared to indirect calorimetry (MMX) among the children across the individual activity stations, lasting 4 minutes in total.

Figure 1. Histogram presenting the median sedentary minutes and 95% confidence intervals for SWA, GT3X and ActivPAL(APAL). All seated- and standing activities were compared, with a total of 12 minutes. All activities were compared with a total of 24 minutes.

Figure 2. Histogram presenting the median sedentary minutes and minimum and maximum values for SWA, GT3X and ActivPAL (APAL) compared to indirect calorimetry (MMX). All seated- and standing activities were compared, with a total of 12 minutes. All activities were compared with a total of 24 minutes.

TABLE 1: Median of minutes spent sedentary and 95% confidence intervals for SWA, GT3X and ActivPAL (APAL) among the children across the individual activity stations, lasting 4 minutes in total.

	Standing Ball- toss	Sitting ball- toss	Musical chairs	Television	Sedentary Gaming	Gaming Move
SWA	0.0 (0.0 , 0.0)	0.0 (0.0 , 0.0)*	0.0 (0.0 , 0.0)	4.0 (2.0 , 4.0)	4.0 (3.0 , 4.0)	0.0 (0.0 , 0.0)
GT3X	0.0 (0.0 , 0.0)	0.5 (0.0 , 1.0)*	0.0 (0.0 , 0.0)	3.0 (2.0 , 4.0)	4.0 (4.0 , 4.0)	0.0 (0.0 , 0.0)
APAL	4.0 (4.0 , 4.0)**	4.0 (3.0 , 4.0)**	4.0 (2.0 , 4.0)**	4.0 (3.0 , 4.0)	4.0 (4.0 , 4.0)	4.0 (3.0 , 4.0)**

*** Significantly different compared to the other monitors (P < 0.05).**
**** Significantly different compared to the other monitors (*P* < 0.001).**

TABLE 1: Median of minutes spent sedentary and 95% confidence intervals for SWA, GT3X, AcitvPAL (APAL) compared to inirect calorimetry (MMX) among the children across the individual activity stations, lasting 4 minutes in total.

	Standing Ball- toss (n=5)	Sitting ball- toss (n=5)	Musical Chairs (n=5)	Television (n=11)	Sedentary Gaming (n=11)	Gaming Move (n=12)
SWA	0.0 (0.0 , 0.0)[1]	0.0 (0.0 , 0.0)[1]	0.0 (0.0 , 0.0)[1]	4.0 (2.0 , 4.0)*	4.0 (2.0 , 4.0)*	0.0 (0.0 , 0.0)
GT3X	1.0 (0.0 , 2.0)[1]	2.0 (1.0 , 3.0)[1]	0.0 (0.0 , 1.0)[1]	3.0 (2.0 , 4.0)*	4.0 (3.0 , 4.0)*	1.0 (0.0 , 2.0)
APAL	4.0 (0.0 , 4.0)[1]	4.0 (2.0 , 4.0)*[1]	1.0 (0.0 , 4.0)[1]	4.0 (3.0 , 4.0)*	4.0 (3.0 , 4.0)*	4.0 (2.0 , 4.0)**
MMX	0.0 (0.0 , 0.0)[1]	0.0 (0.0 , 0.0)[1]	0.0 (0.0 , 0.0)[1]	0.0 (0.0 , 2.0)	0.0 (0.0 , 1.0)	0.0 (0.0 , 0.0)

*** Significantly different compared to indirect calorimetry (MMX) (*P* < 0.05).**
**** Significantly different compared to indirect calorimetry (MMX) (*P* < 0.001).**
[1] 95% confidence interval substituted with minimum and maximum values due to low sample

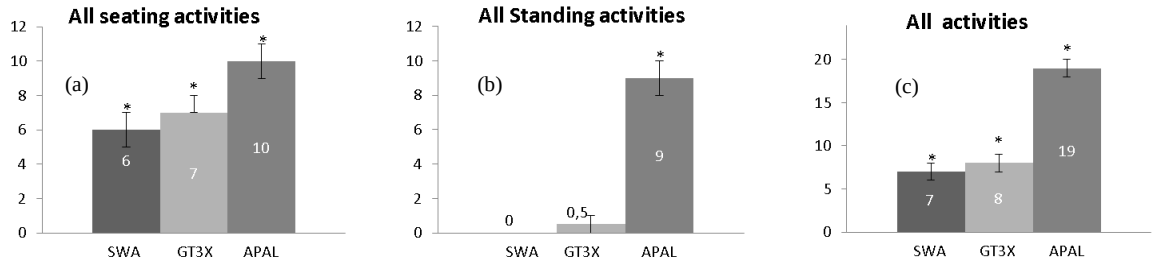


Figure 1- Histogram presenting the median sedentary minutes and 95% confidence intervals for SWA, GT3X and ActivPAL (APAL). All seated- (a) and standing (b) activities were compared, with a total of 12 minutes. All activities (c) were compared with a total of 24 minutes.
***Significantly different compared to the other monitors (P < 0.05).**

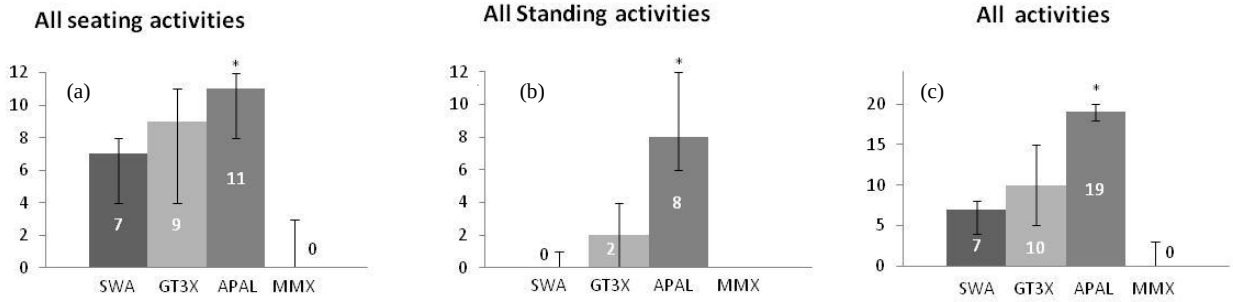
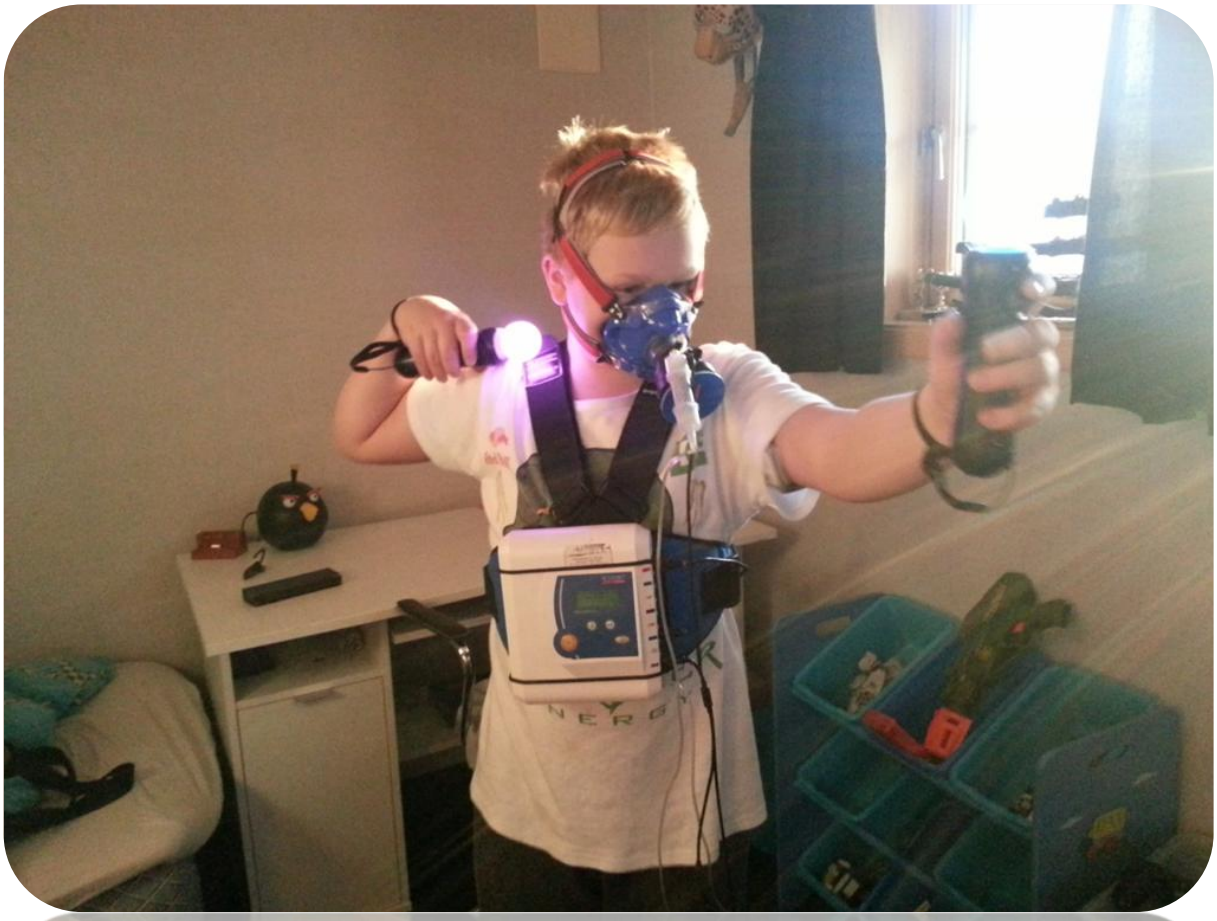
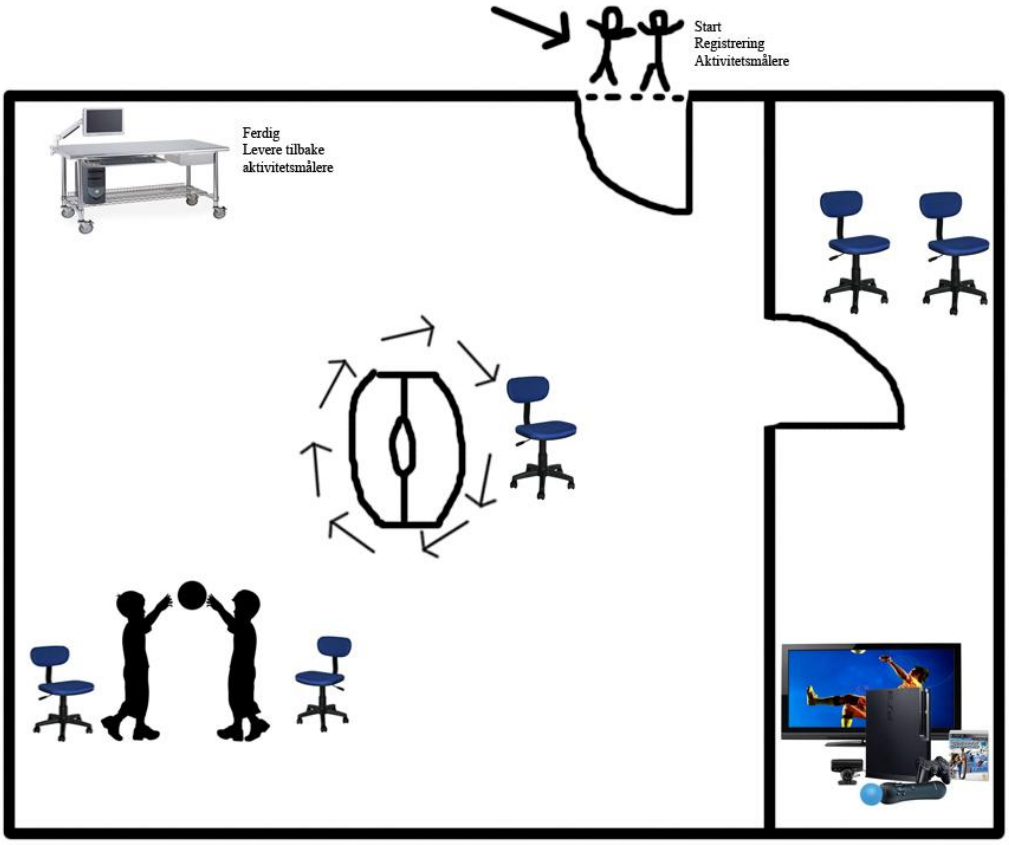


Figure 2- Histogram presenting the median sedentary minutes and minimum and maximum values for SWA, GT3X and ActivPAL (APAL) compared to indirect calorimetry (MMX). All seated- (a) and standing (b) activities were compared, with a total of 12 minutes. All activities (c) were compared with a total of 12 minutes. All activities (c) were compared with a total of 24 minutes. In these histogram n=5.
***Significantly different compared to the other monitors (P < 0.05).**

Forskningsprosjekt Karuss

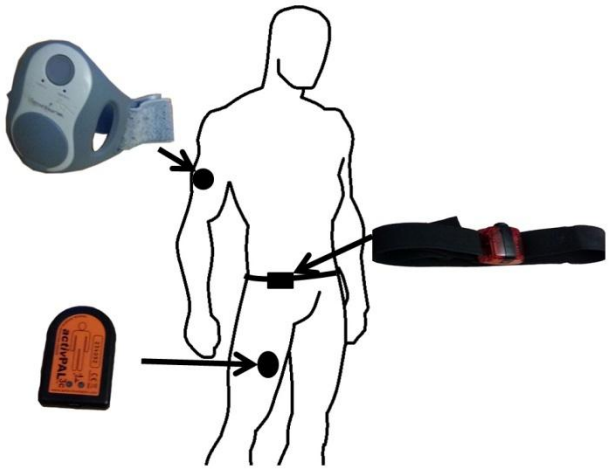
26. NOVEMBER TIL 28. NOVEMBER





Over: Skjema for oppsett av stasjoner på karuss

Til høyre: En skjematisk oversikt over hvor aktivitetsmålerne skal være plassert på testperson. Både Sensewear armband Pro3 og Actigraph gt3x har med belte slik at de enkelt festes på det aktuelle stedet. ActivPAL må festes med en gelé- basert limtype på låret.



Testprosedyre

Oksygenanalysator og de forskjellige aktivitetsmålerne skal festes til deltakerne, som skal være delt inn i grupper på 2 barn. Disse skal gjøre aktiviteter som å spille TV-spill med bevegelses- kontroller, frilek, stillesittende adferd, gymnastikk, ballaktivitet og lesing.

1. Bomba (6 minutter)
2. Ballkasting sittende (6 minutter)
3. Rolig gange/ "stol- leken" (6 minutter)

} Øvelsesgruppe #1

4. TV- titting (6 minutter)
5. Bilspill (7 minutter)
6. Spill med bevegelseskontroller (8 minutter)

} Øvelsesgruppe #2

Totalt 56 minutter, hvor 11 minutter regnes til organisering og påmontering av aktivitetsmålere og Metamax, 39 minutter regnes til aktiviteter og 6 minutter regner til pauser mellom aktivitetene, klargjøring til ny aktivitet og organisering.
Deltakerne utfører disse aktivitetene utsyrt med akselerometrene.

"Bomba"

Deltakerne skal her hive en ball frem og tilbake, mens testleder tar tiden med en stoppeklokke, ca 1 minutt. Når det har gått ett minutt, "sprenger" bomba og den som holder den taper. Ballen skal ikke være i bakken. Deltakerne skal ikke vite hvor mye tid som er igjen, slik at de må gjette når bomben sprenger. Testleder kan si ting som: "Nå er det ikke lenge igjen", "nå sprenger den snart" osv. Dette gjøres tre- fire ganger.

Ballkasting sittende

Denne øvelsen er nesten lik "bomba" (se pkt. 4.4.1.), med en stor forskjell: Øvelsen gjøres sittende uten at det er lov å bevege føttene. Deltakerne skal så hive ballen til hverandre, det er ikke lov å kaste ballen bort eller slik at deltaker ikke får tak i den. Om dette skulle skje skal testleder hente ballen, deltakerne skal IKKE reise seg opp under denne øvelsen. Viktig å huske på å se an hvor langt deltakerne klarer å hive ballen i den posisjonen når man bestemmer hvor langt unna stolene skal plasseres fra hverandre.

Rolig gange/ stolleken

Fortell deltakerne at de skal gå rundt det høye bordet i midten av rommet. Si at nå du sier "NÅ!" må de sette seg ned på stolen som er satt ut ved bordet. Si at det er en konkurranse og at det er juks å gå fort før testleder sier "NÅ!". Eller så ber du de gå i vanlig tempo rundt bordet for å se hvor mange runder de klarer å gå. Da kan du si "den forrige eller beste gruppa klarte 11, få se om dere klarer å slå det!?"

TV titting uten noen spesiell aktivitet

Be deltakerne sitte ned på de to stolene som blir brukt til å spille playstation med vanlige håndkontroller. Be dem se hva de to som spiller playstation move gjør og fortell dem at når de er ferdig skal de spille bilspill.

TV-spill med vanlig, ikke beveglsesavhengig håndkontroll

Be deltakerne om å sette seg på stolene. Start spillet og følg instruksene på skjermen for to spillere og ”split screen”.

TV-spill med bevegelsessensor, stående

Start spillet: PS3;Sports Champions og vent til du er inne på menyen. De to deltakerne skal stå ved siden av hverandre, med ca 1,5 meter i mellom og ca 3 meter fra kameraet. Be den deltakeren som som har kontroll nummer 1 (Denne er den eneste som kan velge noe i menyen) om å velge øvelsen som er nummer to fra venstre: ”Gladiatorkamp”. Be så deltakeren om å velge flerspiller modusen. Etter dette får deltakerne beskjed om å velge om de bruker én eller to kontroller og hvilken hånd de benytter. Be begge deltakerne om å velge én håndkontroll og hvilken hånd de benytter til kontrollen (høyre eller venstre). Velg utøver de vil benytte, prøv å ikke la dette dra ut tiden ved å be dem om å velge fort, gutt eller jente, slik at de får spilt så mye som mulig. Følg deretter kalibreringsinstruksene som kommer opp på skjermen. Etter dette begynner spillet, se an hvor lenge en omgang kommer til å vare og beregn ca 7-8 minutter. Spillet de skal spille vil være en sverdkamp mot hverandre, dette kan bli litt villt, men prøv å la deltakerne få spille så fritt som mulig, så lenge sikkerheten til deltakerne, omgivelsene eller utstyret ikke blir truet. Når tiden er ute be dem om å trykke på ”start”- knappen (er på venstre side av håndkontrollen) og trykke på avslutt.

Prosedyre for datainnsamling og rutiner for sikkerhetskopiering

Data vil bli lastet inn på forskjellige datamaskiner, aktivitetsmålerne på en maskin og Metamax II- og Metamax 3X målingene på en annen maskin. Dette gjøres fordi det er forskjellig kompatibilitet på de forskjellige aktivitetsmålerne og oksygenanalysatorene slik at de ikke kan benyttes på samme operativsystem. Alle filer skal legges i mapper med ID nummer og navn på måleapparat. Sikkerhetskopiering skal gjøres hver dag ved siste innlevering av målere til testleder på TO USB- minnepenner som ikke skal oppbevares

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Til foreldre i 5., 6. eller 7. klasse

Vi håper ditt barn vil delta i et morsomt og viktig forskningsprosjekt

Bakgrunn og hensikt

Dette er et spørsmål til foreldre/foresatte om å la ditt barn delta i en forskningsstudie for å bedre forståelsen av hvordan inaktivitet hos 10-12 åringer kan reduseres og dette vil igjen være viktig for å fremme sunn vektutvikling og god helse. Barn og unge bruker mye tid på å sitte, passiv transport og skjermaktiviteter (TV/PC). Målet med studien er å teste ut hvilken type aktivitetsmåler som fungerer best til å fange opp aktiviteter til barn, da dette er viktig for å forstå barns adferd slik at vi bedre kan foreta valg som kan redusere inaktivitet.

Selve studien

I studien vil 50 elever i alderen 10 og 12 år deltar. De vil bli delt inn i mindre grupper på 5-10 elever. Elevene skal gjennomføre aktiviteter som for eksempel ulike former for TV- spill, lesning og andre stillesittende aktiviteter, samt aktiviteter som krever at elevene er litt mer aktive som stillestående gymnastikk og balltikken. Elevene vil være iført aktivitetsmålere og aktivitetene vil bli organisert som stasjoner i en gymsal/klasserom med forskere tilstede hele tiden. Før elevene tar på seg aktivitetsmålerne vil de bli veid på en vekt og målt høyde av ettersom noen av aktivitetsmålerne bruker høyde og vekt for å regne ut energiforbruk. Er også ønskelig av praktiske grunner at deltakerne møter i gymtøy, og at de går i shorts ettersom den ene aktivitetsmåleren skal festes på låret.

Aktivitetsmålerene vil fange opp aktiviteten slik at vi kan sammenlikne resultatene fra de ulike aktivitetsmålerene. Apparatene likner på skrittellere og måler puls, antall steg og kropps- positur. Ett til to barn i hver gruppe vil få anledning til å prøve en oksygenanalysator som måler oksygenopptak, slik at aktivitetsmålerene kan sammenliknes med dette. Denne oksygenanalysatoren er en liten boks rundt 15x15 cm som bæres på ryggen som en liten sekk. Ut fra denne boksen kommer det en maske med et munnstykke på enden (engangsbruk), og denne vil barnet bli bedt om å puste gjennom under aktivitetene. Denne måler luften som barnet puster inn og puster ut og registrerer dette. Dette apparatet er trygt å bruke og monteres

lett av og på. Det er ikke ubehagelig for barnet å puste gjennom denne masken. Bruk av oksygenanalysator er frivillig.

Prosjektet er organisert slik at først vil forskerene fortelle elevene generelt om forskning, og hvorfor universitetet driver med forskning, og så vil elevene selv være med på den praktiske delen av selve prosjektet.

Hva innebærer studien

I løpet av høsten 2012 vil følgende skje:

Ditt barn blir spurt om å delta i 60 minutter med aktiviteter i et klasserom eller en gymsal iført aktivitetsmålere. Aktivitetene som elevene utfører er som nevnt ovenfor ulike typer TV- spill, lesning og andre stillesittende aktiviteter, samt aktiviteter som krever at elevene er litt mer aktive som stillestående gymnastikk og balltikken. Aktivitetsmålere festes på ulike steder på kroppen som på armen, rundt beinet eller rundt livet. Aktivitetsmålerene likner på avanserte skrittellere og er like trygge å bruke som en skritteller. De er ikke ubehagelige å bruke.

Tilfeldige valgte barn vil bli spurt om å bruke en oksygenanalysator som beskrevet ovenfor under disse aktivitetene.

Mulige fordeler og ulemper

Utenom det som er blitt skissert ovenfor, vil ikke studien føre til ulemper for barnet ditt. Fordelene med studien er at den vil gi økt kunnskap om inaktivitet blant barn og unge. Elevene vil få innsikt i hvordan forskning planlegges og gjennomføres ved at de selv er deltakere, og i tillegg vil det gi økt bevisstgjøring rundt temaet inaktivitet.

Hva skjer med informasjonen om deg og ditt barn

All informasjon angående barna vil være anonymisert og vil utelukkende bli brukt til forskning i henhold til gjeldende nasjonal lovgivning. Opplysningene som innhentes i denne studien er konfidensielle og ingen uvedkommende vil få tilgang til dem. Det vil ikke være mulig å identifisere barna i resultatene av studien når disse publiseres.

Frivillig deltakelse

Det understrekes at det er frivillig å delta i studien. Du kan når som helst, og uten å oppgi noen grunn trekke ditt samtykke tilbake. Dette vil ikke få konsekvenser for ditt barn eller foreldre/foresatte. Dersom du ønsker å la ditt barn delta, undertegner du samtykkeerklæringen på siste side og sender den med barnet til kontaktlærer. Dersom du senere ønsker å trekke deg, så vil innsamlete data bli slettet.

Har du spørsmål eller lurer på noe angående prosjektet, kan du kontakte:

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Telefon: 38 14 16 83 / 41 16 17 90

E-post: jarles08@student.uia.no

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Samtykke til deltakelse i studien (returneres med eleven i konvolutten til kontaktlærer)

Jeg bekreftet å ha mottatt informasjon om studien. Hvis jeg ønsker tilleggsinformasjon, så vet jeg hvem jeg skal kontakte.

Jeg samtykker til at mitt barn deltar i studien som beskrevet i informasjonsbrevet ved å få bruke aktivitetsmåler i 60 minutter.

Jeg har blitt informert om at mitt barns deltagelse er frivillig. Jeg kan når som helst trekke mitt barn fra studien uten å oppgi noen grunn. Hvis mitt barn ikke velger å delta, eller trekker seg fra studien, så vil det ikke medføre noen form for ulemper.

Barnets navn (store bokstaver), klasse (f.eks 6A)

Forelders/foresattes navn (store bokstaver)

Sted og dato Underskrift til forelder/foresatte

Navn på forskere: Førsteamanuensis Sveinung Berntsen, universitetslektor Frøydis Vik, masterstudent Jarle H. Stålesen