# Objective measurement of posture allocation and sedentary behaviours in the pre-school child: a validation study

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# Abstract

Sedentary behaviours contribute to energy imbalance in young children. Time spent sitting may be an important component of sedentary behaviour but validated measures of posture and posture transitions in the pre-school child are lacking. Accelerometer based posture detection systems validated in the adult literature have often shown excellent agreement with the gold standard of direct observation in controlled environments, but their potential use for the young child is likely to be limited by weight and the need to use multiple sensor sites. Single unit sensors are a potentially more practical alternative that may be suitable for use in research involving young children. This thesis describes the validation of two single unit accelerometer based monitors for their ability to each measure posture and postural transition objectively: the *activ*PAL™ (PAL Technologies, UK) and the DynaPort MicroMod MoveMonitor 1.2 (McRoberts, NL). It also compares sedentary behaviours as detected by the *activ*PAL™ and DynaPort monitors with conventional accelerometry using the ActiGraph. The *activ*PAL™ and DynaPort MoveMonitor algorithms for posture and activity identification in comparison to the gold standard of direct observation have been validated in adults. Neither has previously been validated in young children.

A validation study of the *activ*PAL™ and DynaPort MicroMod MoveMonitor involving 30 pre-school children is described. The study took place in each child's usual nursery environment. Children were videoed for one hour undertaking usual activities in nursery while wearing an *activ*PAL™ and DynaPort MicroMod. In addition, children also wore an ActiGraph accelerometer. The ActiGraph does not measure posture but is well established in physical activity research in childhood. It provided objective information about activity intensity (in particular sedentary behaviour) for each child during the observation period. Video (gold standard) was analyzed on a second-by-second basis and compared with monitor output.

From direct video observation, the proportion of time spent during the one hour of video recording was sit/lie 46%; stand 35%; and walk 16%. The remaining 3% of time was spent in non-sit/lie/upright postures (e.g. crawl, crouch, kneel up) although transitions involving these contributed disproportionately to total

posture transitions. The number of sit-stand posture transitions on direct observation was not associated with time spent sedentary. The overall proportion of time detected as 'sit/lie' was 42% and 32% as detected by *activ*PAL™ and DynaPort respectively. Similarly, for *activ*PAL™ and DynaPort detected 'walk', this was 16% and 15% respectively.

Overall sensitivity for time detected as *activ*PAL™ 'sit/lie' was 87%, specificity 97% and positive predictive value 96%. DynaPort MicroMod sensitivity for 'sit' was lower but specificity remained high (91%). There was poor correlation between *activ*PAL™ 'sit/lie' and ActiGraph-defined sedentary behaviour (<1100 counts per minute), r = 0.16. However, there was good correlation (r=0.87) between *activ*PAL™ ['sit/lie' + 'stand'] and ActiGraph defined sedentary behaviour.

The validation results for the *activ*PAL™ were similar to those described in the adult literature and although those for the DynaPort monitor were less good, both show promise as measurement tools in this age group. Single unit accelerometers capable of detecting posture may have a role in the evaluation of sedentary behaviour in young children, beyond the capabilities of currently used objective monitors such as the ActiGraph. However the role of (and importance of objectively capturing) posture transitions, including non-sit/lie/upright postures requires further investigation. Ultimately, knowledge of posture and postural transitions may provide a better understanding of movement and activity in young children. This potential to help evaluate sedentary behaviours is of interest for childhood obesity research.

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# Publications and abstracts

Reilly JJ, Penpraze V, Hislop J, **Davies G**, Grant S, Paton JY.

**Objective measurement of physical activity and sedentary behaviour: review with new data**

Archives of Disease in Childhood. 2008;93(7):614-9

**Davies G**, Reilly JJ, Dall PM, Granat MH, Paton JY

**Validation of the *activ*PAL$^{TM}$ activity monitor during usual nursery activity in pre-school children**

Oral presentation at the British Association of Sports and Exercise Medicine (BASEM) Annual Congress, October 2009

**Davies G**, Reilly JJ, Dall PM, Granat MH, Paton JY

**Single unit monitors for the measurement of posture in young children: validation, challenges and considerations**

To be presented orally at the International Society of Behavioral Nutrition and Physical Activity (ISBNPA) Annual Meeting in Minneapolis US, June 2010

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# Declaration

I declare that the thesis represents my own work except where acknowledged to others. This thesis has not been submitted in any form to any other University.

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# 1 Introduction

## 1.1 Epidemiology of childhood obesity

The evolving childhood obesity epidemic has been extensively reported (1-4). The Health Survey for England 2008 (5) reported that 14% of boys and 13% of girls aged 2 to 10 years were obese according to $95^{th}$ percentiles for BMI based on UK 1990 reference data (6). The prevalence of obesity in older children was greater, with 21% of boys and 18% of girls aged 11 to 15 years obese. Since 1995, the proportion of obese children aged 2-15 has increased from 11% to 17% in boys and 12 to 15% in girls, although the over the past few years the prevalence in boys has remained static and in girls declined slightly. An overweight or obese child is at high risk of becoming an overweight or obese adult (7). A recent large US epidemiological study based on data from their National Health and Nutrition Examination Surveys has described a progressive increasing cumulative prevalence of obesity over the life time of each ten year birth cohort between 1926 and 2005 (8). The birth cohort of 1976 to 1985 had a 20% prevalence of obesity in their twenties but this prevalence was not reached until the thirties for the cohorts born 1946 to 1965 and until the fifties for those born in 1926 to 1935. The problem is global. According to the World Health Organization childhood obesity is one of the most serious public health challenges of the $21^{st}$ century, and estimated that in 2007 over 22 million children worldwide under the age of five years were overweight (9).

## 1.2 Consequences of childhood obesity

Obesity has consequences at every level of the hierarchy of systems from the molecular, cellular or organ level to the levels of society as a whole.

Obesity in childhood is associated with adverse health outcome. This includes disruption to psychological well-being and effects on the cardiovascular, metabolic, pulmonary, gastrointestinal, and skeletal systems (10). In the Bogalusa Heart Study, overweight was associated with more atherosclerotic lesions (an indicator of future cardiovascular morbidity) in major systemic and coronary arteries (11). Obesity in childhood and adolescence is associated with increased risk of cardiovascular disease in adulthood (12). Metabolic consequences of obesity during childhood include decreased insulin sensitivity and increased circulating plasma insulin concentration (13); both important processes in the pathogenesis of type II diabetes. In the gastrointestinal system, obesity in children has been found to be associated with risk of developing non-alcoholic fatty liver disease (14). Progression can lead to chronic inflammatory changes and ultimately cirrhosis and liver failure in adult life.

Functional status on a day to day basis is also impaired. Quality of life assessment in obese children and adolescents has produced results comparable to those seen in childhood malignancy (15).

In addition to associations mentioned above, obesity in adulthood is associated with excess all cause mortality (16) and obesity-related cancers (colon, breast, oesophageal, uterine, ovarian, renal and pancreatic) cause specific mortality(17). It is also associated with type II diabetes (18), osteoarthritis (19), asthma (20), and the chronic bronchitic phenotype of chronic obstructive pulmonary disease (21). In addition to consequences to the individual and family, the economic consequences are substantial, with one estimate of the cost burden being nearly as high as that attributable to smoking (22).

## 1.3 Aetiology of childhood obesity

Obesity results from a chronic imbalance between energy input and expenditure. Total energy expenditure is determined by the basal metabolic rate (the energy used on basic physiological functions e.g. breathing), the thermic effect of food (the energy required for physiological digestion and storage of food), and physical activity. A small net positive energy balance is necessary for normal growth, but a larger net positive energy balance for pre-school children has existed over recent decades promoting excessive weight gain in this age group (23). Obesity reflects a chronic situation of positive energy balance which may develop as a consequence of a small net energy gap each day.

The relative contribution of factors determining energy intake or expenditure to promote this energy imbalance remains poorly understood. Trends in energy intake or dietary behaviours are notoriously difficult to measure. Underreporting can lead to inaccurate assessment of energy intake and raised BMI is associated with a greater bias towards under-reporting (24).

There is some evidence to suggest that reported energy intake in the UK is falling rather than rising (25), especially in young children where the evidence is stronger as dietary intake assessments in children are less prone to bias (in older children and adults under reporting of intake can be substantial (26)).More recent evidence from the US has reported an increase in energy intake amongst adolescents (27). However, total energy intake is difficult to measure at a population level (28).

At present, the relative contribution of energy intake and energy expenditure to overall energy balance remains inconclusive. In this context, it is therefore important to consider the role of non-dietary determinants of energy balance, particularly physical activity. By measuring physical activity, 'risky behaviours' which may have contributed to or help perpetuate energy imbalance (such as sedentary behaviour) can be identified.

A cross sectional study from the UK found that obese school aged children had a tendency to be less active than non-obese children (29). They found that these differences were particularly striking once a child was out of the school environment, i.e. once the children had a greater choice about their activity levels. Being cross sectional in nature, no conclusions can be drawn from such studies in relation to any causal link between obesity and physical activity. And even with evidence from longitudinal epidemiological studies there is still a good deal of uncertainty over the role of physical activity as a cause of obesity (30;31). A chicken and egg situation exists – whether some children are 'programmed' to be inactive and at risk of obesity (from either genetic or gene-environmental interactions) or that increased weight gain dissuades others from being less sedentary and or more active remains to be clearly defined.

A longitudinal study involving pre-school Scottish school children found that the median proportion of time spent sedentary was 79% at three years of age and 76% at five years (32). The proportion of time spent in physical activity defined as being of moderate or vigorous intensity was minimal (2% at three years and 4% at five years). Furthermore, moderate or vigorous physical activity may contribute little to total energy expenditure in young children, but the amount of time spent sedentary might have a greater influence (33). Sedentary behaviours, distinct from levels of physical activity, have therefore gained increasing recognition in terms of their potential role in the energy equation.

## 1.4 Energy expenditure and objective measurement of physical activity

The gold standard methods of assessing energy expenditure are doubly labelled water and indirect calorimetry (34;35). The doubly labelled water technique involves calculating carbon dioxide production using isotope dilution over a predefined period of several days. Doubly labelled water can determine the energy expended during physical activity but is limited by its inability to characterise type or patterns of physical activity over a measurement period; instead it only gives energy expenditure over the specified measurement time (35). Indirect calorimetry, where oxygen consumption and or carbon dioxide production is measured and converted to energy expenditure, is largely restricted to the laboratory setting (34).

Doubly labelled water and indirect calorimetry are both used to assess energy expended during physical activity. Physical activity is defined as any bodily movement produced by skeletal muscle that results in energy expenditure (36). Being able to measure accurately and quantify physical activity, particularly in under free-living conditions is difficult. The gold standard method of measuring physical activity is by direct observation (35). There have been several validation studies of direct observation assessment tools for summarising physical activity in childhood (37-43). Quantification of their ability to predict energy expenditure has been assessed against heart rate variation and oxygen consumption (37;41;43). Direct observation is extremely labour intensive and not practical for large studies involving prolonged periods of data collection in the free-living environment.

Several alternative broad methodologies have been validated for their ability to measure physical activity in free-living conditions. These include self report questionnaires of recent activity history, heart rate monitors, and motion sensors (accelerometers and pedometers)(35). These have, in general, been validated against the criterion standards of energy expenditure (doubly labelled water and indirect calorimetry) or direct observation although increasingly novel methods are being assessed against accelerometry. Heart rate monitoring has been used as a measure of physical activity because of the linear relationship between oxygen consumption and heart rate. However heart rate is not only affected by activity levels but also by emotional and stress responses and there are difficulties with defining resting heart rates in young children (44). Heart rate becomes even less robust as a measure of physical activity when the activity is of low intensity because of the influence of these factors (45).

Accelerometers and pedometers have become established as practical objective measures of physical activity(35;46;47). Accelerometers and pedometers measure motion. Pedometers calculate distance covered and the total number of steps taken in any given period of time. Validation studies suggest good association between pedometers as a measure of step activity in comparison to the ‘gold standard’ of direct observation(48), and similarly with oxygen consumption(49). Accelerometers measure acceleration along a defined axis. Accelerations generated by body movements are either converted to counts or stored as raw acceleration data depending on the type of model used and underlying technology. Accelerometers can be uniaxial, where acceleration is recorded in one plane only, biaxial (two planes of measurement), or tri-axial where acceleration is measured in three dimensions. There are also wide differences in frequency of data capture (termed ‘epochs’), size and weight of sensors, optimal site on body for placement, and axis of measurement between different commercially available units.

There are several commercially available accelerometers but the ActiGraph accelerometer (formerly called the Computer Science and Applications (CSA)) has probably been most widely investigated in children (47;50-53). This uniaxial accelerometer measures acceleration in the vertical plane and stores this information in ‘counts’. Validation against direct observation and energy expenditure has been undertaken in pre-school children (51;53). However a consensus regarding appropriate ‘cut offs’ to define activity intensity has not been reached.

Although accelerometer data can be a valid method of measuring physical activity, converting this to estimations of energy expenditure remains problematic particularly in children. Specific equations have been generated to convert paediatric ActiGraph data into energy expenditure estimation (50;52;54;55). However, a study investigating the predictive validity of energy expenditure equations found that three previously published equations developed for interpreting ActiGraph data in children did not accurately predict energy expenditure for children when walking and running, but faired better as a means for classifying activity intensity (56). Pate et al demonstrated that Actigraph counts correlated with oxygen consumption in pre-school children for moderate and vigorous activity as determined by indirect calorimetry and a structured activity intensity protocol (53). Mapping accelerometer output to energy expenditure at the lower end of the activity intensity spectrum is more problematic.

## 1.5 Sedentary behaviour

There is a need to develop and validate objective techniques that can capture and better define sedentary behaviours as opposed to physical activity alone. The distinction between an mere absence of physical activity versus sedentary behaviour is discussed by Biddle (57). He suggests that ‘physical inactivity’ is an inadequate label to describe patterns of ‘sedentariness’ (sedentary behaviour) because the definition is assuming ‘activity absence’ which ‘fails to capture the complexity of sedentary behaviour’. It is important to know what children are doing when they are sedentary in addition to what they are doing when they are active, and even those that may be considered to have high levels of physical activity may also spend a large proportion of time sedentary and some evidence suggests there is no clear association between the two constructs (58).

There is an increasing body of evidence that inactivity and sedentary behaviours are associated with obesity risk (59-62). Studies have often used surrogate measures of inactivity, such as time spent watching television or self-report to define this risk (59;60). However, subjective reports alone are not sufficient as outcome measures for evaluation the composition of sedentary behaviours. Matthews et al found that children and adults were twice as sedentary than when quantified on the basis of television viewing time alone when an objective (accelerometer defined) measure of sedentariness was used as the outcome measure (63). Robust objective measures are needed. As stated above, accelerometers have been widely used in the assessment of childhood physical activity relevant to the field of obesity (47). However, although able to summarise activity according to activity intensity, standard accelerometers do not give information about body posture, e.g. time spent sitting or standing. Such information may be important for the ability to understand better sedentary behaviour in childhood. In addition, reporting data on total minutes spent according to activity intensity category may not adequately summarise how this time was accumulated. However, accelerometers such as the uniaxial ActiGraph have been used and accepted as providing an objective measure of sedentary behaviour in children (64;65) and there is growing interest in the development and optimisation of systems capable of accurately capturing and defining sedentary behaviours (66;67).

## 1.6 Non exercise activity thermogenesis (NEAT)

There is evidence from the adult literature to suggest that posture allocation is important to the energy balance equation. Levine (61) studied postural allocation and activity in ten lean and ten mildly obese adults and assessed activity related energy expenditure with doubly labelled water. Obese subjects were seated for 164 minutes longer and upright for 152 minutes less than lean subjects. Levine has proposed and defined the concept of non-exercise activity thermogenesis or 'NEAT'(68;69). NEAT is the energy difference between total energy expenditure and that expended as basal metabolic rate, thermic effect of food or intentional exercise. It therefore encompasses activities of daily living and unintentional movements and includes walking, posture variations (e.g. sitting or standing), and fidgeting. Whether or not NEAT exists as a clinically important entity in early life is currently unknown. The distinction between exercise and non-exercise in young children is artificial. Pre-school aged children do not have their activity patterns governed by occupation, or go to the gym or play football for 90 minutes at a time. In adults, occupation or chosen hobbies will help to define the magnitude of their NEAT, in pre-school children choice (or lack of) about their playtime or activity will be influenced by environment, parental influence and lifestyle. However, since low intensity activity probably contributes to the majority of energy expenditure in young children (33) the investigation of posture and fidgeting may be even more important.

## 1.7 Objective measures of posture detection

To date, no objective posture detection methods have been validated in the pre-school child. Furthermore, accelerometer based posture detection systems which have been reported in the literature are often bulky, involve several different sensors and their weight may prohibit utility in a pre-school population (61;70). Lanningham Foster have validated a system in the laboratory capable of detecting posture in school age children but this system relies on multiple sensors being worn in specially adapted shorts and vest and is unlikely to be suitable use for application in pre-school children particularly in the free-living environment (66). However, the development for an activity monitor system to detect posture in young children would potentially help better understand patterns of sedentary behaviours and evaluate the concept of NEAT.

Instead, single unit sensors are a potentially more practical alternative that may be suitable use in research involving young children. Two particular single unit systems of interest are the *activ*PAL™ and the DynaPort MicroMod.

## 1.8 Single unit monitors to detect posture

### *1.8.1 activPAL™ monitor*

The *activ*PAL™ physical activity logger is a small single unit light weight physical activity monitor produced by PAL Technologies Ltd, Glasgow, UK. It measures 35 x 53 x 7mm and weight is 20 g. A photograph of the monitor is shown in figure 1. The monitor is worn on the anterior thigh in the midline and can record posture and activity data over a seven day period. The *activ*PAL™ contains a uni-axial piezoresistive accelerometer and determines posture output on the basis of thigh inclination. The output categories for posture and activity detection are sit/lie, stand and walk. The *activ*PAL™ has been validated for its ability to detect walking (71;72) and posture detection in adults (71;73).


**Figure 1. *activ*PAL™ monitor**

### *1.8.2 DynaPort MicroMod MoveMonitor*

The DynaPort MicroMod (McRoberts B.V, The Hague, The Netherlands) monitor is a single unit device worn around the waist in a neoprene belt with site of monitor placement overlying the lower back. The dimensions of the monitor are 83 x 51 x 8mm with a weight of 40 g. A photograph of the DynaPort MicroMod is shown in figure 2. It is a tri-axial seismic accelerometer which measures gravitational accelerations ('g'). Acceleration data are stored on commercially available Secure Digital (SD) cards and then saved using proprietary software. Data files are then uploaded to a central server (www.gaitweb.nl) for analysis according to the algorithms developed by McRoberts. Reports summarising the data are then emailed to the researcher in a format which describes the proportion of time spent in the output categories sit, lie, stand, walk and shuffle and the number of posture transitions occurring during the measurement period. The MoveMonitor algorithms for posture detection have been recently developed and validated in adults (74).

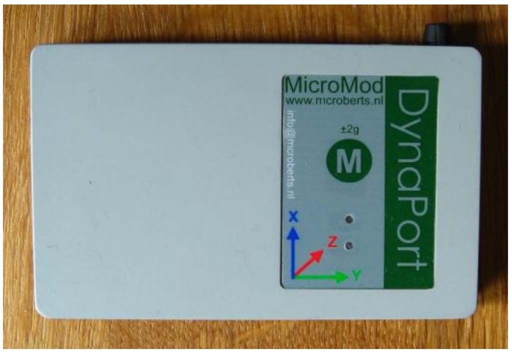



**Figure 2. DynaPort MicroMod monitor**

# 1.9 Hypothesis and Aims

## *1.9.1 Hypothesis*

We hypothesised that the two single unit accelerometer based activity monitors DynaPort MicroMod MoveMonitor (McRoberts) and *activ*PAL™ (PAL Technologies) could both independently capture objective postural and activity data in young children.

## *1.9.2 Aims*

The aim of this study was to validate the *activ*PAL™ and DynaPort MicroMod against the gold standard of direct observation in pre-school children in their usual nursery environment. The secondary aim was to compare whether the posture and activity data collected by these monitors was additional or equivalent to that achievable with standard (non posture detecting) accelerometers such as the commonly used ActiGraph.

# 2 Methods

## 2.1 Overview of study protocol

The study described here is a validation of the *activ*PAL™ and DynaPort MicroMod activity monitors for their ability to both independently detect posture and activity in pre-school children using direct observation as the criterion standard. Simultaneous comparison with the ActiGraph, an accelerometer widely used in physical activity research involving young children, provided an objective measure of physical activity intensity during their data collection period. The study took place within each child's usual nursery school environment and usual activity was not restricted in any way.

Each child wore an *activ*PAL™, DynaPort MicroMod and Actigraph GT1M accelerometer. One hour of time-synchronized video recording was undertaken with the child undertaking usual nursery activity. Filming and data collection occurred over a one hour period for either a single child or two children at any given time. No more than two children wore the monitors simultaneously, limited due to the number of monitor 'sets' available and for practical reasons regarding the opportunity to film multiple children at any one time.

## 2.2 Ethical approval and recruitment

Ethical approval for the study was granted by the Faculty of Medicine Research Ethics Committee for the University of Glasgow. In addition, permission to conduct this research within educational establishments run by Glasgow City Council was granted by Education and Social Work Services. Potential nurseries were identified on the basis of involvement with previous departmental research studies involving measurement of physical activity. Three nurseries were involved in the study; two were privately operated, and one run by Glasgow City Council. Discussion with the nursery head teachers and staff regarding the format of the study was undertaken and information sheets explaining the study provided for the nursery staff and parents. Written parental informed consent was obtained prior to child recruitment to the study. Verbal assent from the children prior to their data collection session was obtained following an explanation in age appropriate language. Parents were also asked to complete a short questionnaire to determine if there were any known pre-existing limitations in their child's ability to walk, stand or sit and whether they used any aids to support this. Only children with no known impairment to mobility were included in the study.

The study was undertaken by a single researcher within the nurseries, the author, who had undergone the appropriate criminal record check (Enhanced disclosure, Disclosure Scotland) prior to work undertaken within the nursery environment.

A convenience sample of 30 children was estimated to be sufficient for the validation study, the same number as recruited to the ActiGraph validation study in pre-school children by Reilly et al (51). Prior to the present study there was no pre-existing data on which to perform a power calculation for a study on the validation of posture allocation methods in young children. All study participants were given a child code to anonymise data. This was in the format N0001, N0002, N0003 etc. according to order of data collection. This allowed linkage of data from the different activity monitors and direct observation.

## 2.3 List of equipment

### *2.3.1 Equipment taken to nursery schools*

- Leicester height measure (height)
- Seca scales (weight)
- Sony High Definition 4.0 Megapixel Handycam digital video camera (HDR-HC5) and digital video tapes (60 minute)
- DynaPort MicroMod x 2 (labelled A and B)
- Neoprene DynaPort MicroMod belts (McRoberts, NL)
- Secure Digital (SD) card (64MB) x 2 and SD card reader (SanDisk® Milpitas, California, US)
- *activ*PAL™ Professional x 2 (labelled A and B), (PAL Technologies, Glasgow, UK)

- ActiGraph™ GT1M x 2 (labelled A and B) on elastic belt, (ActiGraph, Pensacola, Florida,US)
- ActiGraph PC interface cable with USB connection
- PAL*stickies*™ (gel adhesive pads)(PAL Technologies)
- PALdock Charging station (*activ*PAL™ docking station), (PAL Technologies)
- Laptop computer (Samsung V25) with:
    - MIRA software (fro the DynaPort monitors): Version 1.9.4 Build 2 2007. McRoberts BV The Hague, NL
    - PAL (Physical Activity Logging) software (for the *activ*PAL™ monitors): *activ*PAL™ Professional. Research Edition Version 5.8.2.3, PAL Technologies Ltd, Glasgow, UK
    - ActiLife software (for the ActiGraphs): ActiLife Lifestyle Monitoring System Version 3.3.0

### *2.3.2 Additional equipment for data analysis*

- DVD recorder and player

## 2.4 Basic characteristics

Basic characteristics including age, sex, height and weight for each child were recorded. Height was measured in centimetres with children wearing light clothing and shoes removed. Weight was recorded in Kg to the nearest 0.05 kg, with children wearing light clothing and shoes removed. Height and weight data was converted into standard deviation z scores according to UK 1990 reference values (6;75).

## 2.5 Activity monitors

Each child wore one *activ*PAL™, DynaPort MicroMod and ActiGraph GT1M monitor during their period of data collection. Two sets of monitors consisting of one each of an *activ*PAL™, DynaPort MicroMod and GT1M ActiGraph were used for the entire validation study. These sets were labelled A and B for identification, and a list of children for whom each monitor set was used is provided in the Appendix 5.1.

The processes involved for each monitor in terms of preparation for data capture, measurement and saving the data files are described below.

### 2.5.1 activPAL™

The *activ*PAL™ under test was charged prior to use by insertion into the PALdock Charging Station, connected to a laptop via a USB connection. An incompletely charged *activ*PAL™ was indicated by a small orange LED on the *activ*PAL™. This indicator light switched off when the monitor battery was fully charged. The *activ*PAL™ monitor was then transferred from the 'charging' dock to the 'PC interface' dock of the Charging Station where it could 'communicate' with the host computer. This updated the *activ*PAL™ monitor to synchronise with host computer system time (to the second).

The minimum sitting and minimum upright time as detected by *activ*PAL™ was changed from the default of 10 seconds to one second for both in the present study (this can be manually changed within the *activ*PAL™ Professional Research Edition software (Version 5.8.2.3) anywhere from 1 to 100 seconds). Reduction from the default of ten seconds to one second was made because of the interest in postures and posture transitions irrespective of their duration.

There is no 'start' switch on the *activ*PAL™; the monitor is set to start recording immediately when monitor is reprogrammed. Data capture continues until either the internal battery runs out or the *activ*PAL™ is downloaded. Visual identification that the *activ*PAL™ was recording data on removal from the docking station was provided by a flashing LED that continues throughout data recording.

A PAL*stickies*™ gel pad (single use) was attached to the *activ*PAL™ monitor immediately prior to attachment to the child's thigh. With the *activ*PAL™ attached to one side of this double sided sticky gel pad, it was then attached to the child. The monitor was sited on the child's right leg on the anterior thigh midway between the hip and the knee in the midline.

At the end of the videoed data collection period, the *activ*PAL™ monitor was removed from the child's thigh. The PAL*stickies*™ gel pad was peeled away from the monitor and the *activ*PAL™ placed in the PAL dock Charging Station 'PC

Interface' slot. Raw data from the *activ*PAL™ was uploaded via this USB interface to the laptop computer. Data was uploaded by pressing 'communicate' and then 'save activity recording' within the *activ*PAL™ Professional Research Edition software. The data files were assigned a file name according to the date and start time of data recording, and saved as .pal files. The monitors were then reprogrammed to prepare for the next child's data collection if on the same day. For measurements on different days, the *activ*PAL™s were always charged prior to use, despite the total battery life for a fully charged *activ*PAL™ being capable of recording continuously over a seven day period.

### *2.5.2 DynaPort MicroMod*

DynaPort MicroMods were charged via a custom cable (McRoberts, NL) plugged in to mains electricity. A red LED component on the charger unit indicated whether the monitors were charging (red LED on) or fully charged (LED off). As with the *activ*PAL™s, for measurements on different days the monitors were always fully charged prior to the first measurement that day. If more than one measurement took place on a single day, the DynaPorts were not recharged in between children. The duration of the battery within the MicroMod is reported to last for around 72 hours.

Data files for the DynaPort MicroMod are stored on Secure Digital (SD) cards. Before measurements could be recorded, the SD card was 'initialised' within the McRoberts proprietary MIRA software programme (version 1.9.4 Build 2 2007). Data capture was set to record at a frequency of 100Hz (necessary for the McRoberts proprietary algorithms to interpret the saved data files). Initialising a SD card was achieved by inserting the card into a SD card reader connected to the laptop with the MIRA programme open and clicking 'initialise card' in the toolbar menu. The SD card was then ready to be inserted into the charged DynaPort MicroMod to commence measurement. 64MB SD cards were used for all measurements.

Insertion of the SD card into the MicroMod was accompanied by a brief red LED light, which then (within a second) changed to a constant green LED. Acceleration data capture began when the 'M' button on the MicroMod was pressed. This resulted in a change from continuous to intermittent green LED on the DynaPort, and continued throughout recording. Data are captured according to time in seconds and raw acceleration data (in ‘g’) is saved for each of the three axis of accelerometer measurement. Data are saved according to time, with time in seconds starting at zero rather than ‘real’ time.

To determine the actual start time of the DynaPort acceleration data file, time synchronisation with the video and computer system time was achieved as follows: the start of the DynaPort recording was made by videoing the manual pressing of the ‘M’ button on the monitor itself by the researcher whilst video recording was in progress and with concurrent filming of screen clock on laptop computer. Data recording was able to be recognised visually by the flashing of a green LED on the monitor.

The DynaPort MicroMod was then inserted into the monitor pocket in the DynaPort neoprene belt and secured in place with Velcro. With filming still in progress but child not on screen, the researcher put the belt on the child. The belt was placed around the child’s waist, over light clothing, with the MicroMod monitor overlying the child’s lower back. Velcro attachments on the belt were used to adjust to achieve fit.

At the end of the data collection period, belts were removed from the child and the SD card was removed from the MicroMod monitor. Removal of the SD card ended the acceleration data recording. The SD card was inserted into the card reader and using the ‘read card’ function in the MIRA software toolbar the acceleration data was uploaded to the laptop computer and files saved according to child code in .mif and .3ac format.

### *2.5.3 ActiGraph GT1M*

Two GT1M ActiGraphs were used for all data collection. ActiGraphs were charged prior to each use by connecting the monitor to the laptop computer via a USB 2.0 interface cable. Connection between the ActiGraph and the computer also opened the ActiLife software window (ActiLife Lifestyle Monitoring System Version 3.3,0) which was used to define parameters for data collection and download the data. Fully charged monitors were recognized by a continuously lit LED on the device.

The ActiGraph records acceleration data in counts. These counts represent the vertical accelerations detected by the ActiGraph at a frequency of 30 Hertz over the sampling period, which is called an epoch. A 60 second epoch length was used for data collection to allow comparison with previous studies and to use pre-defined cut offs for acceleration counts in this pre-school age group(51). A start time (hh:mm) for acceleration data recording was entered which was in advance of the period of data capture to ensure that counts would be recorded throughout the period of comparison between direct observation and *activ*PAL™ and DynaPort data. No automatic stop time for data recording was entered.

The researcher placed the ActiGraphs on the child. The ActiGraphs were worn on the right hip on an elastic belt over light clothing snugly against the body.

At the end of data collection for each child, the raw acceleration counts were downloaded to a laptop computer. This was achieved according to standard manufacturers recommendations, with the GT1M ActiGraph connected to the laptop via the USB interface as per method of charging the device described above. The output was downloaded from the ActiGraph to computer by the ActiLife software. By clicking the 'Download' button on the ActiLife software, the acceleration 'counts' per minute were downloaded from the monitor and saved in .dat format according to child code.

## 2.6 Video observation

Children were videoed wearing an *activ*PAL™, DynaPort MicroMod and an ActiGraph GT1M for a one hour period. A hand held video camera was used for the data collection that was charged prior to recording to permit mobility of filming. All video recordings were made by the author. Video data were recorded on to tape using a Sony High Definition 4.0 Megapixel Handycam digital video camera (HDR-HC5) with 60 minute duration digital video tapes. These tapes were recorded on to DVD for play back and data analysis.

### *2.6.1 Time synchronisation*

At start of the child's direct observation period, the screen of the same laptop computer used to initialise the activity monitors was filmed with the PC clock on display. This recorded in real time the PC clock to the nearest second, to act as a ‘checking mechanism’ for PC and video camera clock synchronisation during subsequent data analysis and allow any correction if this was discrepant. Synchronisation of time between activity monitors, computer software and video recorder was important to permit comparison of activity monitor output at any individual second. As described, the *activ*PAL™ synchronizes with the operating system time on the computer during set up for recording. The ActiGraph also uses the date and time settings of the computer on which it is initialised prior to use. The DynaPort MicroMod does not synchronise to the computer as stated above, hence the importance of filming the pressing of the start (‘M’) button to identify the start ‘second’ to permit later comparison of output with direct observation data.

### 2.6.2 The observation period

Children wore the *activ*PAL™, ActiGraph GT1M and DynaPort MicroMod monitor throughout the hour’s videoed observation period. During filming, the children’s activity was not restricted in any way and they continued to take part in usual nursery activities. Data collection took place for different children throughout the normal nursery day, and on different days to suit each of the three individual nurseries.

Filming was undertaken in nursery continuously for the hour period where possible. No filming was undertaken whilst children were undertaking personal care (tooth brushing, going in to the bathroom etc), if children not consented to be in video were present, or if this was thought to compromise safety (e.g. no filming took place as children were walking down a main road wearing monitors between two different nursery activities). At the end of the observation period, filming was stopped and all three monitors were removed from the child. Raw data files from each were saved at the end of the observation period as described for each monitor above. Processing of each monitor’s output was not undertaken until the direct observation data had been analysed.

## 2.7 Data analysis

### *2.7.1 Video observation*

Video data was analysed with the clock display (hh:mm:ss) on screen at all times. Videos were analysed by a single observer. Posture, activity and any additional comments were recorded according to time (hh:mm:ss), on a second by second basis. Where a change in posture or activity occurred, the time and nature of this was documented. Analysis of the 1 hour video recordings took 4-5 hours per child. Where two children were on the same tape (i.e. simultaneous data collection), observation data was analysed for each child in succession. The following parameters were documented for each recording:

- Time on video camera clock and simultaneous time on PC clock (hh:mm:ss)
- Time DynaPort A start, Time DynaPort B start (if second child on video), defined as described above by pressing the 'M' button on the monitor.
- Child code identification (e.g. N0001,N0002) and identification feature of child (e.g. wearing white shorts)
- Time child first in video (start of comparisons) and posture/activity at this time
- Posture and activity: the start time (hh:mm:ss) of any transition to a new posture or activity
- Any other comments (such as a child touching their *activ*PAL$^{TM}$)

The time that the child was first on screen defined the start second following which all direct observation data was compared with monitor output. The time (second) the child was last on screen defined the end of the period of observation for each child.

Posture and activity were recorded according to the time in seconds on the video clock at which they occurred. There was no minimum duration of any single posture. More than one posture or activity could occur within an individual second and if this occurred both postures were documented at the same second. Sitting was defined as a posture in which the child's buttocks were in contact with a solid surface and weight bearing. It included children sitting down on the floor cross-legged, sitting on a chair, sitting on an armchair and kneeling down.

Kneeling down (classified as sitting) was differentiated from kneeling up (classified as ‘other’) by whether the buttocks were in contact with the floor or heels of the child’s shoes. Peddling on a tricycle (with the child sitting) was documented separately on the initial direct observation data for identification purposes and subsequently grouped with ‘sit’. Standing was defined as upright posture without transition in location. It was sometimes difficult to define whether a child was standing or walking, particularly when standing playing with toys or at the sandpit. Standing with legs straight but bending forward was coded as standing. The direct observation category ‘walk’ included run, jump, skip, and dancing. Lying was defined as any posture in which the trunk was in contact with and parallel to the floor/furniture. All seconds when the child was either ‘off screen’ or ‘obscured’ (by another child or furniture) were coded as off screen or obscured. ‘Not filmed’ described periods where an interruption to filming occurred for e.g. safety reasons as described above, and ‘off’ was used to code seconds where a child had taken a monitor off.

The posture categorisation scheme described above generated thirteen initial categories of direct observation data which were subsequently summarised into five main direct observation categories and one describing total seconds ‘off screen’ as shown in table 1.

| **Initial direct observation category** | **Main direct observation category** |
|---|---|
| Sit<br>Kneel down<br>Peddle | Sit |
| Lie | Lie |
| Stand | Stand |
| Walk<br>Run<br>Dance<br>Jump | Walk |
| Crouch<br>Kneel up<br>Crawl<br>Other | Other |
| Obscured<br>Off screen<br>Not filmed<br>Off | Off screen |

**Table 1 Direct observation categories**

The direct observation ‘other’ category included postures that did not sit comfortably within definitions of walk, stand, sit or lie and included a heterogeneous assortment of postures. This included crouching down (squatting), kneeling up, crawling and other postures requiring a diagram (other) to explain. Schematic representations of these are shown in figures 3 to 6.

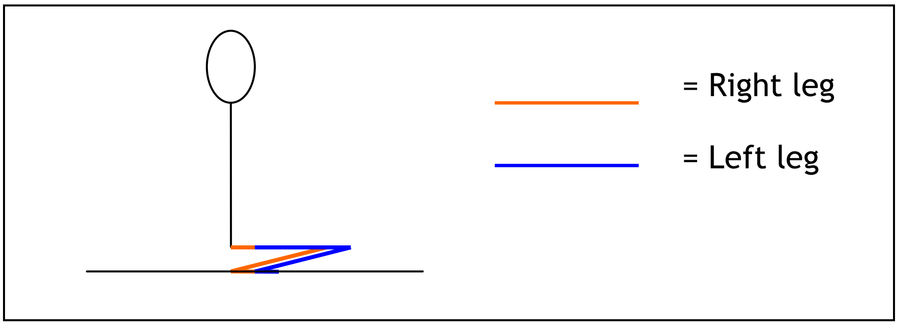



**Figure 3. Schematic representation of child crouching (squatting)**

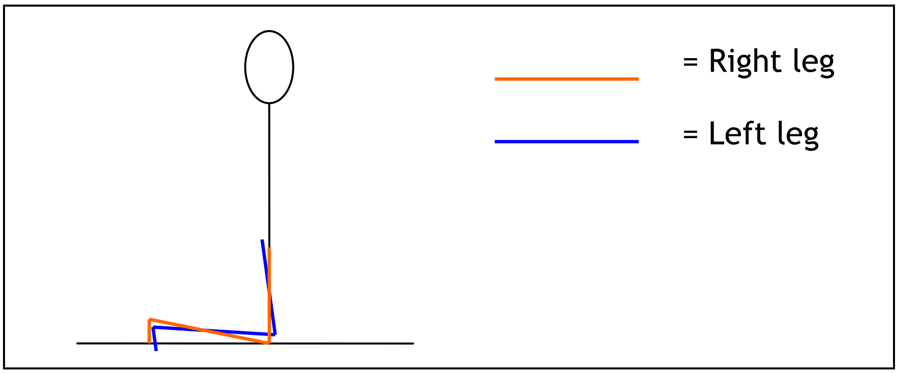



**Figure 4. Schematic representation of child kneeling up**

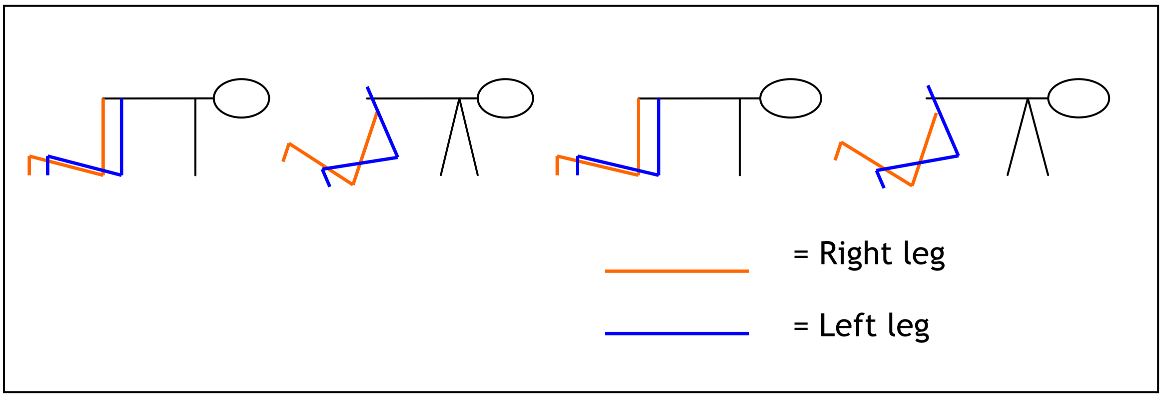



**Figure 5. Schematic representation of child crawling**

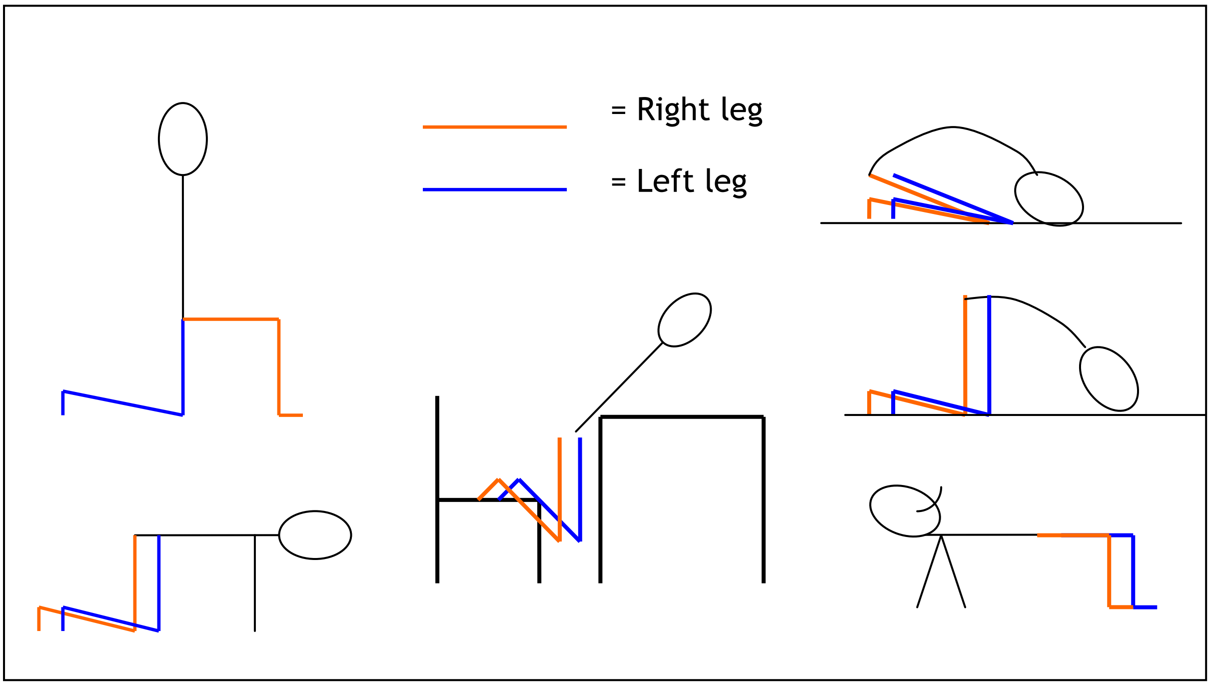



**Figure 6. Schematic representation of examples of 'other' postures**

Examples of child postures included in the 'other' group which required a diagram to define are shown. Clockwise from top right: 'fetal' position, 'fetal' position with thighs perpendicular to floor, 'crab' position, hanging off the end of a chair and leaning on a table, static crawl position, kneeling on one knee.

### 2.7.2 activPAL$^{TM}$ monitor

The *activ*PAL$^{TM}$ Professional Research Edition software (version 5.8.2.3) classifies all data into one of the following categories: Sit/lie, stand and walk (this software also detects the number of steps taken and activity intensity, however neither of these outcomes were included in the validation study described here). There is no 'unknown' category for output. The .pal files generated by the *activ*PAL$^{TM}$ Professional Research Edition software were imported into HSC PAL analysis software (version 2.14) developed by Professor Malcolm Granat's research team at the School of Health and Social Care (HSC), Glasgow Caledonian University. This software allows detailed analysis of the *activ*PAL$^{TM}$ output as classified by the original *activ*PAL$^{TM}$ Professional Research Edition software by listing the time (in seconds) at which a change in output category (i.e. a transition) occurred. It does not alter the output category assigned by original analysis of the raw data by the *activ*PAL$^{TM}$ Professional Research Edition software. Use of the HSC software allowed comparison with time-matched direct observation data for validation purposes.

### 2.7.3 DynaPort MicroMod activity monitor

Raw acceleration data files (in .3ac format with file name according to child code) were uploaded to the password protected Gaitweb (McRoberts, NL) server (www.gaitweb.nl) for analysis. Subject data on Gaitweb was also labelled according to child code (e.g. N0001) to identify each child in the analysis reports. An artificial time of data collection was entered to allow subsequent time matching with the direct observation data. This artificial time was set at 00:00:00 hours on each date of measurement. This was necessary because there was no opportunity to time synchronise the monitor to PC operating time prior to data capture, and post-data collection enter of the start time on the server was accurate to time in minutes. The 00:00:00 start time was chosen as all data could be plotted in real time from this point to the end of the measurement period (i.e. the second at which the 'M' button was pressed was considered time point 00:00:00).

Raw data were analysed with the MoveMonitor (version 1.2) algorithms. These identify, through analysis of the tri-axial acceleration signals, the posture of the subject. All data were categorised into one of the following five: locomotion, stand, shuffle, sit and lie. Reports summarising the signal analysis are sent from the server by email. The period between requesting a report and receiving the detailed analysis output was usually less than five minutes. Two reports options were possible for each uploaded file in the format of either 'Numerical' or 'Graphical' files. The Numerical files were in a Microsoft excel format, and list the output category (as described) according to time. An example is given in the Appendix. Excel spreadsheets were created with consecutive seconds from 00:00:00 to the end of file, and this was subsequently incorporated with the DynaPort Numerical file (see Appendix). The graphical file was not used for analysis, as this gave a summary of output for the entire measurement period rather than the period on screen on which all comparisons were made. Otherwise, any seconds between starting the DynaPort recording and the child wearing the monitor (e.g. when putting the belts on) and similarly at the end of measurement period until the SD card is taken out would have been included.

## 2.8 Creating comparison spreadsheets for data analysis

The Microsoft Word tables generated from the direct observation data were imported in to Excel spreadsheets. Each row in the spreadsheet was designed to represent an individual second (or part-second in which two transitions occurred, see below) during data collection for an individual child. Raw direct observation data defining the time (in seconds) at which a change in posture/movement was initiated allowed subsequent completion of spreadsheets with allocation of a direct observation category to all seconds throughout the data collection period.

Similarly *activ*PAL™ and DynaPort outputs following signal analysis by their respective software algorithms allowed each second (or part-second in which the monitor detected two transitions, see below) throughout data collection to be allocated a monitor output category. The outputs for both the *activ*PAL™ and the DynaPort monitors defined the time of transition between output categories, thus enabling each second throughout the entire data collection period to be allocated the output category accordingly.

To allow comparison between the direct observation data and the *activ*PAL$^{TM}$ or DynaPort monitor output, it was important that spreadsheet rows (i.e. seconds) were accurately aligned. This was straightforward for the vast majority of seconds where only one direct observation category or *activ*PAL$^{TM}$ or DynaPort category was assigned. However, it was possible that in either direct observation data or monitor output, more than one new change in category ('transition') could occur, for example if a child crouches down and stands up within a single second. It was considered important to include all such transitions, however brief, to ensure that none were missed during data analysis. To facilitate the inclusion of these transitions irrespective of origin (direct observation or monitor output), any second in which more than one transition occurred was split and an artificial comparison 'second' was created at an identical time point in the comparison data output. This meant that all remaining second time points in both direct observation and *activ*PAL$^{TM}$ or DynaPort output remained correctly time-aligned.

To prevent the introduction of these artificial 'seconds' introducing a greater error than necessary, comparison was limited to direct observation against *activ*PAL$^{TM}$ or direct observation against DynaPort MoveMonitor output. Every duplicate second in either video or monitor output creates a degree of error in the output that is artificially expanded to compensate for this. Therefore, by limiting comparison to two variables (e.g. video and *activ*PAL$^{TM}$) the number of artificial comparison seconds was limited.

The number of duplicate seconds generated by the DynaPort MoveMonitor algorithm was noted to be in excess to that from either the direct observation or *activ*PAL$^{TM}$ outputs. To minimise the potential for error by artificially expanding the direct observation data when comparing with DynaPort output, any single seconds containing the transition between stand and shuffle according to DynaPort were considered single seconds only. This was done by keeping the first posture identified by the DynaPort MoveMonitor for that second, and deleting the latter. The number of seconds affected by >1 transition within a single second is shown in the Results chapter.

### 2.8.1 Comparing time-matched seconds for sensitivity, specificity and positive predictive values

To compare only time ‘on screen’, the time-aligned data (output) from direct observation, *activ*PAL™ and DynaPort monitors were filtered to exclude any seconds in which the direct observation data had been coded as off screen (as defined above). Filtering was done using the ‘sort by’ function in Excel. As all comparisons for sensitivity, specificity and positive predictive value were made according to each second (rather than relationships between different seconds), this process of excluding off screen time did not affect results. Data were then exported from Excel to Minitab®(version 15.1) for analysis.

The total number of seconds in each direct observation category and each monitor output category were calculated. In addition, using the ‘Table of descriptive statistics’ function in Minitab®, data was summarised for time-matched seconds according to direct observation category and monitor output category, for both the *activ*PAL™ and the DynaPort MicroMod. Sensitivity, specificity and positive predictive values (PPVs) were calculated for the *activ*PAL™ and DynaPort independently. To determine the sensitivity, specificity and PPV of each monitor output category, the following definitions were used: True positives were defined as all time-matched seconds in which the monitor output category and the direct observation category were identical. False positives were defined as all time-matched seconds in which the monitor output detected the category of interest but this did not agree with direct observation. True negatives were all time-matched seconds correctly identified as not being the category of interest. False negatives were defined as all time-matched seconds not detected by the monitor as the category of interest despite being in this category according to direct observation.

Sensitivity was then calculated according to standard practice as [total number of seconds ‘true positive’]/[total number of seconds ‘true positive’ + ‘false negative’] x 100. Specificity was calculated as [total number of seconds ‘true negative’/[total number of seconds ‘true negative’ + ‘false positive’] x 100. Positive predictive value was calculated as [total number of seconds ‘true positive]/[total number of seconds ‘true positive’ + ‘false positive’] x 100.

Sensitivity, specificity and PPV for each monitor output category were calculated per child. In addition, the summed total time matched seconds for all children were used to calculate overall sensitivity, specificity and PPV according to the same definition. Because direct observation data included the category 'other', and this was not a possibility for monitor output, specificity and PPVs were calculated both including and excluding all seconds in direct observation 'other' (crawl, kneel up, crouch, and other). Data for each approach are presented separately in full in the Results chapter.

### 2.8.2 Postural transitions

Postural transitions between categories of direct observation data or monitor output were identified by looking at the relationship between consecutive seconds throughout data collection. By identifying the relationship between adjacent seconds, any change in observation category between one second and the next represented a transition. A Macro for analysis of adjacent seconds of direct observation categories in this way was kindly written on request by S.Beaton (University of Glasgow). The Macro was modified by the author to analyse *activ*PAL™ and DynaPort MicroMod MoveMonitor data using the same approach. These were used to define the number of transitions between each direct observation category for the entire data collection period for each child. They were also used to compare the number of transitions for direct observation, *activ*PAL™ and DynaPort output for the longest period when the child was on screen continuously without interruption/obscuring of their view. This is referred to as the 'longest uninterrupted period', and defined the seconds between which the number of posture transitions on *activ*PAL™, DynaPort MicroMod and direct observation were compared directly with each other. This prevented 'unseen' transitions that may not have been captured on screen (e.g. child sitting down inside a Wendy house out of view) being used in any comparison between posture detection methods.

Posture transitions may be useful as a proxy for fidgeting, which Levine (61) has suggested might be an important source of inter-individual variation in energy expenditure.

### 2.8.3 ActiGraph data

ActiGraph counts were imported into Excel spreadsheets for analysis. As stated, the GT1M ActiGraph model was used. Although this is the current commercially available ActiGraph, validation studies defining optimal cut points for activity intensity have been carried out using older models such as the ActiGraph 7164. This included the study defining ActiGraph cut offs in pre-school children by Reilly et al (51). Recent evidence has demonstrated that the two models are not equivalent for output in terms of counts per minute (76-78). Corder et al suggest a correction factor of 9.1% to ActiGraph GT1M counts when comparing to the 7164 model (77). A pragmatic correction factor of 10% was applied to raw counts for the study described here.

Taking this correction factor in to account, acceleration counts per minute were summarised as a proportion of time spent within categories of activity intensity. The following definitions were applied in terms of acceleration count cut offs: Sedentary (<1100 counts/minute), Active (≥1100 counts/minute), and Light (<3200 counts/minute), Moderate (3200 to <8200 counts/minute) and Vigorous ≥8200 counts/minute)(33;51). For comparison, a cut of defined by Puyau for sedentary behaviour was also applied (50).

## 2.9 Outcome measures

### 2.9.1 Primary outcome

The primary outcome of interest was validation of the output of the *activ*PAL™ and DynaPort MicroMod monitors against direct observation in pre-school children undertaking usual nursery activity. This included accuracy of detection for each output category and comparison of postural transitions between direct observation and monitor output.

### 2.9.2 Secondary outcome

Objective assessment of activity intensity during the data collection was obtained using GT1M ActiGraphs and comparison was made against output of the *activ*PAL™ and DynaPort MicroMod monitors for each child.

## 2.10 Statistics

Microsoft Excel (Microsoft Office 2003, Microsoft) was used to compose the spreadsheets in preparation for comparisons. Minitab (Version 15.1 English) statistical software was used to generate tally counts of individual variables, and descriptive statistics for categorical variables. Sensitivity, specificity and positive predictive values were defined and calculated for each monitor output category as described above. Graphs and tables were prepared using Excel or Minitab programmes. Pearson correlation coefficients were calculated using Minitab. Spearman rank order correlations were also performed using Minitab by first ranking the data in ascending order according to variable of interest and subsequently calculating the correlation coefficient. For all statistical tests a p value of $<0.05$ was considered significant. Bland Altman bias and 95% limits of agreement were defined using GraphPad Prism (San Diego, California, US) software version 4.03 for Windows.

# 3 Results

## 3.1 Participants

Children were recruited from three nursery schools in Glasgow. Thirty two children participated in the study with a mean age of 4.1 years. Basic descriptive information for all children is shown in table 2. The mean standard deviation scores (SDS) were 0.6 for height, 0.8 for weight and 0.6 for body mass index (BMI). Three children had a BMI SDS above normal (>2). No child had a height, weight or BMI SDS below normal (<2). Complete data sets (defined as video observation, *activ*PAL™, DynaPort MicroMod and ActiGraph data files) were available for 30/32 children. One child only wanted to wear the DynaPort MicroMod and ActiGraph and not the *activ*PAL™ monitor. Her reason for not wanting to wear the *activ*PAL™ was because of its stickiness, referring to the adhesive PAL*stickies*™ gel pad used to attach the monitor to the thigh. The other child with an incomplete data set had missing DynaPort data files (researcher error).

There was no difference in baseline characteristics between all children and children with a complete data set. All comparison analyses were undertaken with the data from 30 children with a full data set.

| Child | Nursery | Decimal age (years) | Gender | Height (cm) | Height SDS | Weight (kg) | Weight SDS | BMI (kg/m$^2$) | BMI SDS |
|---|---|---|---|---|---|---|---|---|---|
| N0001 | 1 | 4.37 | F | 108.0 | 0.92 | 17.70 | 0.34 | 15.17 | -0.30 |
| N0002 | 1 | 4.28 | F | 111.0 | 1.81 | 21.75 | 1.92 | 17.65 | 1.30 |
| N0003 | 1 | 4.53 | F | 111.5 | 1.43 | 20.60 | 1.29 | 16.57 | 0.68 |
| N0004 | 1 | 4.39 | F | 118.5 | 3.38 | 31.55 | 4.10 | 22.47 | 3.33 |
| N0005 | 1 | 4.58 | F | 107.5 | 0.40 | 21.60 | 1.57 | 18.69 | 1.83 |
| N0006 | 1 | 4.09 | F | 102.5 | 0.08 | 18.15 | 0.80 | 17.28 | 1.07 |
| N0007 | 1 | 4.63 | M | 112.0 | 1.15 | 21.60 | 1.53 | 17.22 | 1.19 |
| N0008 | 1 | 4.48 | M | 102.5 | -0.78 | 15.25 | -1.20 | 14.52 | -1.01 |
| N0009 | 1 | 3.99 | F | 107.0 | 1.37 | 20.70 | 1.86 | 18.08 | 1.52 |
| N0010 | 1 | 4.18 | F | 107.0 | 1.03 | 18.80 | 0.98 | 16.42 | 0.55 |
| N0011 | 1 | 3.82 | M | 103.5 | 0.55 | 17.55 | 0.67 | 16.38 | 0.45 |
| N0012 | 1 | 4.33 | M | 107.8 | 0.71 | 20.35 | 1.37 | 17.51 | 1.34 |
| N0013 | 1 | 4.53 | F | 104.6 | -0.17 | 16.30 | -0.46 | 14.90 | -0.49 |
| N0014 | 1 | 4.14 | F | 105.8 | 0.80 | 16.15 | -0.16 | 14.43 | -0.95 |
| N0015 | 2 | 3.38 | M | 101.5 | 0.84 | 17.70 | 1.18 | 17.18 | 0.90 |
| N0016 | 2 | 3.20 | M | 96.7 | -0.07 | 18.00 | 1.52 | 19.25 | 2.13 |
| N0017 | 2 | 4.23 | F | 104.0 | 0.21 | 17.30 | 0.30 | 15.99 | 0.27 |
| N0018 | 2 | 4.43 | F | 106.5 | 0.44 | 17.70 | 0.28 | 15.61 | 0.03 |
| N0019 | 2 | 4.33 | F | 103.4 | -0.12 | 15.15 | -0.87 | 14.17 | -1.13 |
| N0020 | 2 | 3.13 | F | 96.5 | 0.27 | 13.00 | -0.92 | 13.96 | -1.62 |
| N0021 | 2 | 3.42 | F | 109.5 | 3.15 | 27.55 | 4.42 | 22.98 | 3.63 |
| N0023 | 1 | 4.16 | F | 109.0 | 1.54 | 18.00 | 0.66 | 15.15 | -0.35 |
| N0024 | 1 | 4.09 | F | 102.8 | 0.16 | 18.20 | 0.82 | 17.22 | 1.04 |
| N0025 | 3 | 3.76 | M | 100.0 | -0.22 | 14.95 | -0.66 | 14.95 | -0.77 |
| N0027 | 3 | 4.89 | M | 110.6 | 0.40 | 22.25 | 1.50 | 18.19 | 1.78 |
| N0028 | 3 | 4.46 | M | 104.8 | -0.21 | 17.30 | -0.08 | 15.75 | 0.10 |
| N0029 | 2 | 3.16 | F | 98.5 | 0.76 | 16.00 | 0.82 | 16.49 | 0.47 |
| N0030 | 3 | 4.49 | F | 103.9 | -0.28 | 17.05 | -0.07 | 15.79 | 0.17 |
| N0031 | 3 | 3.97 | F | 101.5 | 0.05 | 17.90 | 0.82 | 17.37 | 1.12 |
| N0032 | 3 | 3.31 | M | 95.9 | -0.48 | 14.40 | -0.53 | 15.66 | -0.29 |

**Table 2. Basic descriptive information on participating children (n = 30)**

Height, weight and body mass index (BMI) standard deviation scores (SDS) based on UK 1990 child reference data (6;75).

## 3.2 Description of data collected

Data collection occurred in child pairs or for a single child. Whether a child wore the monitors on their own or at the same time as another child depended on which children were in nursery on a particular day and was guided by nursery staff in terms of suggesting which children were likely to play together. No stipulations were made on the children's activities during the monitoring period. Activity undertaken was variable between children dependent in part on normal nursery curriculum and play during the filmed time. This included structured lesson time (e.g. entire class in music lesson or gym class), meal or snack times, group games, and free play (both indoor and out). The proportion of free play was variable between children, with some having all videoed time as free play or others having almost all in structured group lessons. For 17/30 children, the entire measurement period was indoors. The remaining thirteen children's measurement period included a proportion of outside play, with the duration of this outdoor time determined by the individual nursery timetable.

Two children (N0011, N0032) requested to take off the monitors before the end of the observation period; one appeared to associate the monitors with a play activity and decided he did not want to wear them anymore, and the other wanted to take them off before going to play outside. Both children wore them on a second occasion on a different day to complete data collection. Two other children (N0009, N0013) had a second period of monitoring to complete data collection, as the first was interrupted by another child being videoed at the same time taking part in completely separate activities part way through the measurement period.

The total number of seconds included in the direct observation comparison data analysis for each child is shown in tables 3 and 4. The number of additional 'seconds' generated in response to two posture or activity transitions occurring within a single second (e.g. sit stand) in video, *activ*PAL$^{TM}$ or DynaPort MicroMod output are also shown (tables 3 and 4). These artificial seconds generated at the corresponding real-time second in the comparison data sheet allowed correct time (second) alignment as described in the Methods chapter. The median proportion of duplicate seconds in comparison to total seconds for the direct observation /*activ*PAL$^{TM}$ analyses was 0.15% per child (interquartile range 0.08-0.32%).

DynaPort output generated considerably more duplicate transitions within a single second. To minimise the number of artificial 'seconds' in the comparison direct observation data, those transitions that were of a 'stand shuffle' (or 'shuffle stand') nature were disregarded (with the second transition within the second deleted) as described in Methods. The original and revised number of seconds which contained more than one transitions for the DynaPort output and DynaPort output and direct observation data combined are shown in tables (3 and 4). Taking this revision in to account, the median proportion of duplicate seconds in comparison to total seconds for the direct observation and DynaPort MicroMod analyses was 0.36% per child (interquartile range 0.22 – 0.62%).

| | N0001 | N0002 | N0003 | N0004 | N0005 | N0006 | N0007 | N0008 | N0009 | N0010 | N0011 | N0012 | N0013 | N0014 | N0015 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total monitored time (seconds ) | **3439** | **3340** | **3432** | **3429** | **3287** | **3486** | **3620** | **3620** | **4817** | **3648** | **3917** | **3615** | **3598** | **4019** | **3546** |
| Number of direct observation seconds with >1 transition | 2 | 7 | 1 | 0 | 7 | 17 | 1 | 1 | 3 | 8 | 2 | 12 | 3 | 5 | 10 |
| Number of *activ*PAL$^{TM}$ seconds with > transition. | 1 | 4 | 1 | 0 | 2 | 7 | 0 | 0 | 1 | 5 | 1 | 4 | 0 | 2 | 2 |
| Combined *activ*PAL$^{TM}$ + video seconds with >1 transition | 3 | 11 | 2 | 0 | 9 | 24 | 1 | 1 | 4 | 13 | 3 | 16 | 3 | 6* | 12 |
| Revised total monitored time for *activ*PAL$^{TM}$ and direct observation comparisons (sec) | **3442** | **3351** | **3434** | **3429** | **3296** | **3510** | **3621** | **3621** | **4821** | **3661** | **3920** | **3631** | **3601** | **4025** | **3558** |
| % artificial 'seconds' for observation and *activ*PAL$^{TM}$ comparisons | 0.09 | 0.33 | 0.06 | 0.00 | 0.27 | 0.69 | 0.03 | 0.03 | 0.08 | 0.36 | 0.08 | 0.44 | 0.08 | 0.15 | 0.34 |
| Number of DynaPort MicroMod seconds with >1 transition. | 11 | 12 | 19 | 17 | 29 | 34 | 42 | 51 | 7 | 43 | 8 | 37 | 12 | 51 | 37 |
| Number of DynaPort MicroMod seconds with >1 transition with all stand-shuffle transitions in same second removed | 4 | 1 | 6 | 9 | 7 | 15 | 5 | 12 | 1 | 16 | 1 | 8 | 4 | 24 | 14 |
| Combined DynaPort MicroMod (revised) and direct observation seconds with >1 transition | 8 | 8 | 7 | 9 | 14 | 32 | 6 | 13 | 3 | 24 | 3 | 20 | 7 | 28** | 23*** |
| Revised total monitored time for DynaPort MicroMod and direct observation comparisons (sec) | **3445** | **3348** | **3439** | **3438** | **3301** | **3518** | **3626** | **3633** | **4831** | **3672** | **3920** | **3635** | **3605** | **4047** | **3569** |
| % artificial 'seconds' for observation and DynaPort MicroMod comparisons | 0.17 | 0.24 | 0.20 | 0.26 | 0.43 | 0.92 | 0.17 | 0.36 | 0.29 | 0.66 | 0.08 | 0.55 | 0.19 | 0.70 | 0.65 |

**Table 3 Total monitoring time and number of seconds with >1 transition within single second for child N0001-N0015**

**Table 3. Total monitoring time and number of seconds with >1 transition within single second for child N0001-N0015**

Revised total number of 'seconds' on which data comparisons made between either direct observation and *activ*PAL™ or direct observation and DynaPort MicroMod output take into account seconds with >1 transition

* N0014 Single identical second with two transitions for both video and *activ*PAL™ output.

** N0014 Single identical second with two transitions for both video and DynaPort output.

*** N0015 Single identical second with two transitions for both video and DynaPort output

| | N0016 | N0017 | N0018 | N0019 | N0020 | N0021 | N0023 | N0024 | N0025 | N0027 | N0028 | N0029 | N0030 | N0031 | N0032 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total monitored time (seconds ) | **3545** | **3666** | **3616** | **3616** | **3594** | **3512** | **5038** | **4272** | **3668** | **3902** | **3902** | **3496** | **3716** | **5346** | **3964** |
| Number of direct observation seconds with >1 transition | 1 | 1 | 3 | 2 | 21 | 15 | 6 | 9 | 5 | 6 | 4 | 15 | 7 | 5 | 1 |
| Number of *activ*PAL™ seconds with > transition. | 2 | 2 | 0 | 4 | 7 | 3 | 6 | 3 | 1 | 1 | 1 | 7 | 2 | 3 | 1 |
| Combined *activ*PAL™ + video seconds with >1 transition | 3 | 3 | 3 | 5$ | 28 | 18 | 12 | 12 | 6 | 7 | 5 | 22 | 9 | 8 | 2 |
| Revised total monitored time for *activ*PAL™ and direct observation comparisons (sec) | **3548** | **3669** | **3619** | **3621** | **3622** | **3530** | **5050** | **4284** | **3674** | **3909** | **3907** | **3518** | **3725** | **5354** | **3966** |
| % artificial 'seconds' for observation and *activ*PAL™ comparisons | 0.08 | 0.08 | 0.08 | 0.14 | 0.78 | 0.51 | 0.24 | 0.28 | 0.16 | 0.18 | 0.13 | 0.63 | 0.24 | 0.15 | 0.05 |
| Number of DynaPort MicroMod seconds with >1 transition. | 37 | 10 | 14 | 15 | 19 | 67 | 34 | 50 | 11 | 28 | 41 | 75 | 20 | 44 | 53 |
| Number of DynaPort MicroMod seconds with >1 transition with all stand-shuffle transitions in same second removed | 13 | 5 | 5 | 4 | 4 | 37 | 9 | 27 | 3 | 8 | 13 | 41 | 6 | 16 | 15 |
| Combined DynaPort MicroMod (revised) and direct observation seconds with >1 transition | 14 | 6 | 8 | 5$$ | 25 | 50$$$ | 15 | 35$$$$ | 8 | 14 | 17 | 56 | 13 | 21 | 16 |
| Revised total monitored time for DynaPort MicroMod and direct observation comparisons (sec) | **3559** | **3672** | **3624** | **3621** | **3619** | **3562** | **5053** | **4307** | **3676** | **3916** | **3919** | **3552** | **3729** | **5367** | **3980** |
| % artificial 'seconds' for observation and DynaPort MicroMod comparisons | 0.39 | 0.16 | 0.22 | 0.14 | 0.70 | 1.42 | 0.30 | 0.82 | 0.22 | 0.36 | 0.44 | 1.60 | 0.35 | 0.39 | 0.40 |

**Table 4 Total monitoring time and number of seconds with >1 transition within single second for child N0016-N0032**

**Table 4. Total monitoring time and number of seconds with >1 transition within single second for child N0016-N0032**

Revised total number of 'seconds' on which data comparisons made between either direct observation and *activ*PAL$^{TM}$ or direct observation and DynaPort MicroMod output take into account seconds with >1 transition

$ N0019 Single identical second with two transitions for both video and *activ*PAL$^{TM}$ output.

$$ N0019 Single identical second with two transitions for both video and DynaPort output.

$$$ N0021 Two seconds in which two transitions occurred within the same second for both video and DynaPort output.

$$$$ N0024 Single identical second with two transitions for both video and DynaPort output.

## 3.3 Video direct observation

The number of seconds spent in each video observation category for all children with a complete data set are shown in tables 5 to 12. Tables 5 to 8 summarise the data from direct observation and *activ*PAL$^{TM}$, and tables 9 to 12 that of direct observation and DynaPort MicroMod. The difference in total measured time and total on screen time per child reflects the differences in the number of seconds with two transitions and duplicates as defined above.

The actual total measured time for n=30 children was 113666 seconds (31.6 hours). Including the seconds with >1 transition, the cumulative total number of 'seconds' from all children on which comparisons between direct observation data and *activ*PAL$^{TM}$ output were made was 97,750 'seconds', with a total measured time (on and off screen from start of measurement) of 113917 'seconds' . For DynaPort comparisons this was 97,933 'seconds' (27.2 hours), with total measured time 114183 'seconds'.

The total number of on screen and off screen seconds per child is shown in tables 5 to 12. Reasons for being 'Off screen' during the monitoring period were variable: obscuring of the screen view occurred when the child being filmed was behind an obstacle, including the physical environment (items of furniture, shrubs or trees, Wendy (play) houses) and other children (either unintentionally or through inquisitiveness and a wish to deliberately appear on the film too). Time off screen or not filmed occurred when the child left the main nursery areas e.g. to go to the toilets, or when the video recording was temporarily stopped midway through the measurement period. This was done when the likely time off screen would be prolonged (e.g. entire class in toilets brushing teeth) or for reasons of safety (children, nursery staff and researcher) such as when children were walking outside along a main road to get to another building. Although no filming occurred during these times, all three activity monitors were still recording and therefore the total duration of measured time for these children was variable. Comparisons between direct observation and *activ*PAL$^{TM}$ or DynaPort MicroMod output were made during all seconds with the child visible on screen. Comparisons between ActiGraph GT1M and *activ*PAL™ or DynaPort MicroMod output were made for the total measured time.

Cumulative direct observation data for all children showed that 46% of on screen time was spent sitting or lying (44% sitting, 2% lying), 35% standing, 16% walking and 3% in other postures. These ‘other’ postures include those defined in the Methods chapter and are discussed in more detail below.

The proportion of time spent in each category however was variable between children, reflecting the different activities being undertaken during the periods of measurement. Similarly, not all postures were demonstrated by all children, in particular only 15/30 children lay down during the measurement period, and often this was of brief duration.

The inter-child range in the proportion of time spent sitting during the on screen measurement period was 2-87% for sit/lie, 6-92% for standing, and 3-54% for walking. The inter-child range in proportion of time in ‘other’ postures was 0.1-10%.

### *3.3.1 Sitting/Lying*

Video data of time spent in a sitting posture included children sitting on a chair, on the floor (including with legs crossed in front of body, and kneeling down) and on other items of furniture or equipment. Differences in the method of a child sitting on a chair when sitting at a table were noted. This included sitting towards the front of the chair with one or both thighs hanging down towards the floor, sitting on a chair with one or both feet tucked under their buttocks or sitting leaning to one side. Several positions adopted by children on chairs were not coded as sitting, but as ‘other’, and these are discussed below. Two children sat peddling on tricycles during observation (N0021 and N0029).

### *3.3.2 Posture and activity classified as ‘other’*

All 30 children had >1 second of direct observation data coded as ‘other’. The postures and activities classified as ‘other’ were varied. As discussed in Methods, ‘Other’ was composed of the initial video observation categories of crawl, crouch, kneel up, and ‘other’. The number of seconds per child spent in each of these categories is shown in tables 5 to 12. 14/30 (47%) children crawled, 24/30 (80%) children crouched down and 23/30 (77%) knelt up on ≥1 occasion during the observation period. The remaining seconds classified as 'other' encompassed a heterogeneous collection of postures which required a diagram (figure 6) as described in Methods.

### 3.3.3 Video direct observation: results tables

| | N0001 | N0002 | N0003 | N0004 | N0005 | N0006 | N0007 | N0008 | N0009 | N0010 | N0011 | N0012 | N0013 | N0014 | N0015 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **No. seconds in video observation category** | | | | | | | | | | | | | | | |
| Crawl | | | | | 12 | 4 | | | 12 | | 3 | 16 | 4 | | |
| crouch | 26 | 14 | 4 | 5 | 29 | 38 | | 15 | 12 | 96 | | 15 | 11 | 24 | 114 |
| dance | | | | | | | | | | | | | | 20 | 14 |
| Jump | | | | | 9 | 5 | | 1 | 3 | 6 | 2 | 1 | 39 | 6 | |
| kneel up | 18 | 12 | | | 89 | 85 | | | 4 | 57 | 2 | 142 | 138 | | 3 |
| obscured | 7 | | | 97 | 33 | 264 | 4 | 4 | 59 | 229 | 13 | 189 | 10 | 415 | 224 |
| off screen | 173 | 32 | 286 | 306 | 911 | 261 | 11 | 186 | 566 | 669 | 156 | 60 | 13 | 947 | 162 |
| off | | | | | | | | | | | | | | | |
| lie | | | | | 330 | 191 | | | | | 3 | 11 | | | 1 |
| not filmed | | | | | | | | | 347 | | | | | | |
| other | | | | 15 | 75 | 14 | 16 | 3 | 46 | 39 | 7 | 59 | 7 | 16 | |
| peddle | | | | | | | | | | | | | 0 | | |
| run | | | 36 | 85 | 357 | 465 | | | 61 | 550 | | 22 | 14 | 105 | 23 |
| sit | 2002 | 1492 | 1365 | 1318 | 436 | 1101 | 175 | 66 | 2686 | 814 | 3256 | 1673 | 2129 | 1392 | 668 |
| skip | | 2 | | | | 3 | | | 7 | | | 8 | | 9 | |
| stand | 1013 | 1513 | 1572 | 1501 | 620 | 501 | 3256 | 3147 | 477 | 739 | 356 | 1201 | 924 | 478 | 1783 |
| walk | 203 | 286 | 171 | 102 | 395 | 578 | 159 | 199 | 541 | 462 | 122 | 234 | 312 | 613 | 566 |
| Total monitored time | 3442 | 3351 | 3434 | 3429 | 3296 | 3510 | 3621 | 3621 | 4821 | 3661 | 3920 | 3631 | 3601 | 4025 | 3558 |
| **Total on screen time (seconds)** | **3262** | **3319** | **3148** | **3026** | **2352** | **2985** | **3606** | **3431** | **3849** | **2763** | **3751** | **3382** | **3578** | **2663** | **3172** |

**Table 5 Direct observation raw data for *activ*PAL$^{TM}$ validation, child N0001-N0015.**

| | N0001 | N0002 | N0003 | N0004 | N0005 | N0006 | N0007 | N0008 | N0009 | N0010 | N0011 | N0012 | N0013 | N0014 | N0015 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Cumulative totals for direct observation (seconds)** | | | | | | | | | | | | | | | |
| Sit/lie | 2002 | 1492 | 1365 | 1318 | 766 | 1292 | 175 | 66 | 2686 | 814 | 3259 | 1684 | 2129 | 1392 | 669 |
| Other | 44 | 26 | 4 | 20 | 205 | 141 | 16 | 18 | 74 | 192 | 12 | 232 | 160 | 40 | 117 |
| Stand | 1013 | 1513 | 1572 | 1501 | 620 | 501 | 3256 | 3147 | 477 | 739 | 356 | 1201 | 924 | 478 | 1783 |
| walk | 203 | 288 | 207 | 187 | 761 | 1051 | 159 | 200 | 612 | 1018 | 124 | 265 | 365 | 753 | 603 |
| Off screen | 180 | 32 | 286 | 403 | 944 | 525 | 15 | 190 | 972 | 898 | 169 | 249 | 23 | 1362 | 386 |
| Total | 3442 | 3351 | 3434 | 3429 | 3296 | 3510 | 3621 | 3621 | 4821 | 3661 | 3920 | 3631 | 3601 | 4025 | 3558 |
| **Cumulative percentages for direct observation on screen time only** | | | | | | | | | | | | | | | |
| Sit/lie | 61.4 | 45.0 | 43.4 | 43.6 | 32.6 | 43.3 | 4.9 | 1.9 | 69.8 | 29.5 | 86.9 | 49.8 | 59.5 | 52.3 | 21.1 |
| Other | 1.3 | 0.8 | 0.1 | 0.7 | 8.7 | 4.7 | 0.4 | 0.5 | 1.9 | 6.9 | 0.3 | 6.9 | 4.5 | 1.5 | 3.7 |
| Stand | 31.1 | 45.6 | 49.9 | 49.6 | 26.4 | 16.8 | 90.3 | 91.7 | 12.4 | 26.7 | 9.5 | 35.5 | 25.8 | 17.9 | 56.2 |
| Walk | 6.2 | 8.7 | 6.6 | 6.2 | 32.4 | 35.2 | 4.4 | 5.8 | 15.9 | 36.8 | 3.3 | 7.8 | 10.2 | 28.3 | 19.0 |
| Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

**Table 6 Direct observation summary data for *activ*PAL™ validation, child N0001-N0015.**

| | N0016 | N0017 | N0018 | N0019 | N0020 | N0021 | N0023 | N0024 | N0025 | N0027 | N0028 | N0029 | N0030 | N0031 | N0032 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **No. seconds in video observation category** | | | | | | | | | | | | | | | |
| crawl | | 9 | | | 15 | | 34 | | 23 | 15 | 44 | | 3 | 3 | |
| crouch | | | 12 | 14 | 37 | 13 | 31 | 1 | 1 | | | 36 | 7 | 1 | 18 |
| dance | | | 14 | | | | | | | | | | 7 | | 17 |
| jump | 7 | | | | 57 | 3 | 27 | 16 | 6 | | | 56 | 10 | 4 | 14 |
| kneel up | 17 | 3 | 44 | 144 | 12 | | 7 | 42 | 8 | 7 | 155 | | 16 | 48 | 60 |
| obscured | 89 | 52 | 27 | 6 | 17 | 197 | 67 | 259 | 23 | | 2 | 130 | 40 | | 48 |
| off screen | 265 | 251 | 258 | 185 | | 342 | 132 | 526 | 227 | 804 | 183 | 278 | 65 | 16 | 33 |
| off | | | | | 78 | | | | | | | | 140 | | 9 |
| lie | | 545 | 4 | | 377 | 6 | 139 | 10 | 3 | | 4 | 7 | 8 | | |
| not filmed | | | | | | | 1582 | 574 | 71 | 292 | 314 | | 96 | 1785 | 70 |
| other | 2 | 66 | 71 | 2 | 89 | 10 | 256 | 149 | 60 | 6 | 28 | 41 | 26 | 21 | 12 |
| peddle | | | | | | 322 | | | | | | 276 | | | |
| run | 21 | | | | 14 | 262 | 81 | 357 | 16 | | 52 | 265 | 7 | 11 | 16 |
| sit | 963 | 2287 | 2425 | 2942 | 1369 | 578 | 1663 | 1261 | 1602 | 907 | 1540 | 386 | 1867 | 2316 | 366 |
| skip | | | | | | | | 14 | | | | 13 | | | |
| Stand | 1729 | 301 | 584 | 209 | 1071 | 592 | 730 | 514 | 1439 | 1455 | 1268 | 682 | 950 | 1019 | 2468 |
| Walk | 455 | 155 | 180 | 119 | 486 | 1205 | 301 | 561 | 195 | 423 | 317 | 1348 | 483 | 130 | 835 |
| Total | 3548 | 3669 | 3619 | 3621 | 3622 | 3530 | 5050 | 4284 | 3674 | 3909 | 3907 | 3518 | 3725 | 5354 | 3966 |
| **Total on screen time (sec)** | **3194** | **3366** | **3334** | **3430** | **3527** | **2991** | **3269** | **2925** | **3353** | **2813** | **3408** | **3110** | **3384** | **3553** | **3806** |

**Table 7 Direct observation raw data for *activ*PAL$^{TM}$ validation, child N0016-N0032**

| Cumulative totals for direct observation (seconds) | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **N0016** | **N0017** | **N0018** | **N0019** | **N0020** | **N0021** | **N0023** | **N0024** | **N0025** | **N0027** | **N0028** | **N0029** | **N0030** | **N0031** | **N0032** |
| Sit/lie | 963 | 2832 | 2429 | 2942 | 1746 | 906 | 1802 | 1271 | 1605 | 907 | 1544 | 669 | 1875 | 2316 | 366 |
| Other | 19 | 78 | 127 | 160 | 153 | 23 | 328 | 192 | 92 | 28 | 227 | 77 | 52 | 73 | 90 |
| Stand | 1729 | 301 | 584 | 209 | 1071 | 592 | 730 | 514 | 1439 | 1455 | 1268 | 682 | 950 | 1019 | 2468 |
| walk | 483 | 155 | 194 | 119 | 557 | 1470 | 409 | 948 | 217 | 423 | 369 | 1682 | 507 | 145 | 882 |
| Off screen | 354 | 303 | 285 | 191 | 95 | 539 | 1781 | 1359 | 321 | 1096 | 499 | 408 | 341 | 1801 | 160 |
| Total | 3548 | 3669 | 3619 | 3621 | 3622 | 3530 | 5050 | 4284 | 3674 | 3909 | 3907 | 3518 | 3725 | 5354 | 3966 |
| **Cumulative percentages for direct observation on screen time only** | | | | | | | | | | | | | | | |
| Sit/lie | 30.2 | 84.1 | 72.9 | 85.8 | 49.5 | 30.3 | 55.1 | 43.5 | 47.9 | 32.2 | 45.3 | 21.5 | 55.4 | 65.2 | 9.6 |
| Other | 0.6 | 2.3 | 3.8 | 4.7 | 4.3 | 0.8 | 10.0 | 6.6 | 2.7 | 1.0 | 6.7 | 2.5 | 1.5 | 2.1 | 2.4 |
| Stand | 54.1 | 8.9 | 17.5 | 6.1 | 30.4 | 19.8 | 22.3 | 17.6 | 42.9 | 51.7 | 37.2 | 21.9 | 28.1 | 28.7 | 64.8 |
| Walk | 15.1 | 4.6 | 5.8 | 3.5 | 15.8 | 49.1 | 12.5 | 32.4 | 6.5 | 15.0 | 10.8 | 54.1 | 15.0 | 4.1 | 23.2 |
| Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

**Table 8 Direct observation summary data for *activ*PAL™ validation, child N0016-N0032**

| | N0001 | N0002 | N0003 | N0004 | N0005 | N0006 | N0007 | N0008 | N0009 | N0010 | N0011 | N0012 | N0013 | N0014 | N0015 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **No. seconds in video observation category** | | | | | | | | | | | | | | | |
| crawl | | | | | 12 | 4 | | | 12 | | 3 | 16 | 4 | | |
| crouch | 26 | 13 | 4 | 5 | 29 | 37 | | 15 | 12 | 95 | | 15 | 11 | 24 | 115 |
| dance | | | | | | | | | | | | | | 20 | 14 |
| jump | | | | | 9 | 6 | | 1 | 3 | 6 | 2 | 1 | 39 | 6 | |
| kneel up | 18 | 12 | | | 89 | 84 | | | 4 | 57 | 2 | 142 | 138 | | 3 |
| obscured | 7 | | | 97 | 33 | 265 | 4 | 4 | 60 | 231 | 13 | 189 | 10 | 423 | 225 |
| off screen | 173 | 32 | 287 | 309 | 912 | 262 | 11 | 188 | 566 | 671 | 156 | 60 | 13 | 952 | 162 |
| off | | | | | | | | | | | | | | | |
| lie | | | | | 330 | 190 | | | | | 3 | 11 | | | 1 |
| not filmed | | | | | | | | | 347 | | | | | | |
| other | | | | 16 | 75 | 13 | 16 | 3 | 46 | 39 | 7 | 59 | 7 | 16 | |
| peddle | | | | | | | | | | | | | | | |
| run | | | 36 | 85 | 356 | 468 | | | 61 | 550 | | 22 | 14 | 105 | 23 |
| sit | 2001 | 1489 | 1366 | 1318 | 436 | 1100 | 175 | 66 | 2685 | 814 | 3255 | 1672 | 2129 | 1392 | 670 |
| skip | | 2 | | | | 3 | | | 7 | | | 8 | | 9 | |
| stand | 1013 | 1513 | 1572 | 1501 | 623 | 503 | 3258 | 3153 | 477 | 743 | 357 | 1204 | 925 | 481 | 1785 |
| walk | 207 | 287 | 174 | 107 | 397 | 583 | 162 | 203 | 551 | 466 | 122 | 236 | 315 | 619 | 571 |
| Total monitored time | 3445 | 3348 | 3439 | 3438 | 3301 | 3518 | 3626 | 3633 | 4831 | 3672 | 3920 | 3635 | 3605 | 4047 | 3569 |
| **Total on screen time (seconds)** | **3265** | **3316** | **3152** | **3032** | **2356** | **2991** | **3611** | **3441** | **3858** | **2770** | **3751** | **3386** | **3582** | **2672** | **3182** |

**Table 9 Direct observation raw data for DynaPort MicroMod validation, child N0001-N0015**

| | N0001 | N0002 | N0003 | N0004 | N0005 | N0006 | N0007 | N0008 | N0009 | N0010 | N0011 | N0012 | N0013 | N0014 | N0015 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Cumulative totals for direct observation (seconds)** | | | | | | | | | | | | | | | |
| Sit/lie | 2001 | 1489 | 1366 | 1318 | 766 | 1290 | 175 | 66 | 2685 | 814 | 3258 | 1683 | 2129 | 1392 | 671 |
| Other | 44 | 25 | 4 | 21 | 205 | 138 | 16 | 18 | 74 | 191 | 12 | 232 | 160 | 40 | 118 |
| Stand | 1013 | 1513 | 1572 | 1501 | 623 | 503 | 3258 | 3153 | 477 | 743 | 357 | 1204 | 925 | 481 | 1785 |
| walk | 207 | 289 | 210 | 192 | 762 | 1060 | 162 | 204 | 622 | 1022 | 124 | 267 | 368 | 759 | 608 |
| Off screen | 180 | 32 | 287 | 406 | 945 | 527 | 15 | 192 | 973 | 902 | 169 | 249 | 23 | 1375 | 387 |
| Total | 3445 | 3348 | 3439 | 3438 | 3301 | 3518 | 3626 | 3633 | 4831 | 3672 | 3920 | 3635 | 3605 | 4047 | 3569 |
| **Cumulative percentages for direct observation on screen time only** | | | | | | | | | | | | | | | |
| Sit/lie | 61.3 | 44.9 | 43.3 | 43.5 | 32.5 | 43.1 | 4.8 | 1.9 | 69.6 | 29.4 | 86.9 | 49.7 | 59.4 | 52.1 | 21.1 |
| Other | 1.3 | 0.8 | 0.1 | 0.7 | 8.7 | 4.6 | 0.4 | 0.5 | 1.9 | 6.9 | 0.3 | 6.9 | 4.5 | 1.5 | 3.7 |
| Stand | 31.0 | 45.6 | 49.9 | 49.5 | 26.4 | 16.8 | 90.2 | 91.6 | 12.4 | 26.8 | 9.5 | 35.6 | 25.8 | 18.0 | 56.1 |
| Walk | 6.3 | 8.7 | 6.7 | 6.3 | 32.3 | 35.4 | 4.5 | 5.9 | 16.1 | 36.9 | 3.3 | 7.9 | 10.3 | 28.4 | 19.1 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

**Table 10 Direct observation summary data for DynaPort MicroMod validation, child N0001-N0015**

| | N0016 | N0017 | N0018 | N0019 | N0020 | N0021 | N0023 | N0024 | N0025 | N0027 | N0028 | N0029 | N0030 | N0031 | N0032 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **No. seconds in video observation category** | | | | | | | | | | | | | | | |
| crawl | | 8 | | | 15 | | 33 | | 23 | 14 | 43 | | 3 | 3 | |
| crouch | | | 12 | 14 | 37 | 13 | 31 | 1 | 1 | | | 36 | 7 | 1 | 18 |
| dance | | | 14 | | | | | | | | | | 7 | | 17 |
| jump | 7 | | | | 57 | 3 | 27 | 16 | 6 | | | 57 | 11 | 4 | 14 |
| kneel up | 17 | 3 | 44 | 144 | 12 | | 7 | 43 | 8 | 7 | 155 | | 16 | 48 | 60 |
| obscured | 90 | 52 | 27 | 6 | 17 | 199 | 67 | 260 | 23 | | 2 | 130 | 40 | | 48 |
| off screen | 268 | 251 | 259 | 184 | | 346 | 133 | 528 | 227 | 806 | 184 | 283 | 66 | 17 | 33 |
| off | | | | | 78 | | | | | | | | 140 | | 9 |
| lie | | 545 | 4 | | 377 | 6 | 138 | 10 | 3 | | 4 | 7 | 8 | | |
| not filmed | | | | | | | 1588 | 577 | 73 | 295 | 318 | | 96 | 1797 | 71 |
| other | 2 | 66 | 71 | 2 | 89 | 10 | 255 | 151 | 60 | 6 | 28 | 42 | 26 | 21 | 12 |
| peddle | | | | | | 327 | | | | | | 281 | | | |
| run | 21 | | | | 14 | 265 | 81 | 358 | 16 | | 53 | 267 | 7 | 11 | 16 |
| sit | 962 | 2287 | 2425 | 2942 | 1367 | 580 | 1663 | 1261 | 1602 | 907 | 1541 | 386 | 1867 | 2314 | 365 |
| skip | | | | | | | | 14 | | | | 13 | | | |
| Stand | 1733 | 302 | 584 | 209 | 1070 | 595 | 730 | 518 | 1439 | 1456 | 1270 | 688 | 950 | 1020 | 2475 |
| Walk | 459 | 158 | 184 | 120 | 486 | 1218 | 300 | 570 | 195 | 425 | 321 | 1362 | 485 | 131 | 842 |
| Total monitored time | 3559 | 3672 | 3624 | 3621 | 3619 | 3562 | 5053 | 4307 | 3676 | 3916 | 3919 | 3552 | 3729 | 5367 | 3980 |
| **Total on screen time (seconds)** | **3201** | **3369** | **3338** | **3431** | **3524** | **3017** | **3265** | **2942** | **3353** | **2815** | **3415** | **3139** | **3387** | **3553** | **3819** |

**Table 11 Direct observation raw data for DynaPort MicroMod validation, child N0016-N0032**

| | N0016 | N0017 | N0018 | N0019 | N0020 | N0021 | N0023 | N0024 | N0025 | N0027 | N0028 | N0029 | N0030 | N0031 | N0032 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Cumulative totals for direct observation (seconds)** | | | | | | | | | | | | | | | |
| Sit/lie | 962 | 2832 | 2429 | 2942 | 1744 | 913 | 1801 | 1271 | 1605 | 907 | 1545 | 674 | 1875 | 2314 | 365 |
| Other | 19 | 77 | 127 | 160 | 153 | 23 | 326 | 195 | 92 | 27 | 226 | 78 | 52 | 73 | 90 |
| Stand | 1733 | 302 | 584 | 209 | 1070 | 595 | 730 | 518 | 1439 | 1456 | 1270 | 688 | 950 | 1020 | 2475 |
| walk | 487 | 158 | 198 | 120 | 557 | 1486 | 408 | 958 | 217 | 425 | 374 | 1699 | 510 | 146 | 889 |
| Off screen | 358 | 303 | 286 | 190 | 95 | 545 | 1788 | 1365 | 323 | 1101 | 504 | 413 | 342 | 1814 | 161 |
| Total | 3559 | 3672 | 3624 | 3621 | 3619 | 3562 | 5053 | 4307 | 3676 | 3916 | 3919 | 3552 | 3729 | 5367 | 3980 |
| **Cumulative percentages for direct observation on screen time only** | | | | | | | | | | | | | | | |
| Sit/lie | 30.1 | 84.1 | 72.8 | 85.7 | 49.5 | 30.3 | 55.2 | 43.2 | 47.9 | 32.2 | 45.2 | 21.5 | 55.4 | 65.1 | 9.6 |
| Other | 0.6 | 2.3 | 3.8 | 4.7 | 4.3 | 0.8 | 10.0 | 6.6 | 2.7 | 1.0 | 6.6 | 2.5 | 1.5 | 2.1 | 2.4 |
| Stand | 54.1 | 9.0 | 17.5 | 6.1 | 30.4 | 19.7 | 22.4 | 17.6 | 42.9 | 51.7 | 37.2 | 21.9 | 28.0 | 28.7 | 64.8 |
| Walk | 15.2 | 4.7 | 5.9 | 3.5 | 15.8 | 49.3 | 12.5 | 32.6 | 6.5 | 15.1 | 11.0 | 54.1 | 15.1 | 4.1 | 23.3 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

**Table 12 Direct observation summary data for DynaPort MicroMod validation, child N0016-N0032**

## 3.4 *activPAL™* output

An example section from one individual child's (N0001) *activ*PAL™ posture and activity output data file (using the HSC software described) is shown in the Appendix 5.2. All data within the total measurement time was included in each analysis, with comparisons between direct observation and *activ*PAL™ output made for on screen time only.

## 3.5 DynaPort MicroMod output

An example section from one individual child's (N0001) DynaPort MicroMod posture and activity output data file (using 'Numerical' file format) is shown in Appendix 5.3. All data within the total measurement time was included in each analysis, with comparisons between direct observation and DynaPort MicroMod output made for on screen time only.

## 3.6 ActiGraph monitor

GT1M ActiGraph counts (with an additional 10% correction as described in Methods) provided an objective measure of activity levels over the entire measurement period. Because all data were collected using a 60 second epoch, any ActiGraph counts occurring in minutes during the measurement period were included (i.e. if a child was on screen wearing all monitors for the first time at 10.07.07 and this marked the time of the start of comparison data, ActiGraph counts/min were used from 10:07:00 onwards). The total number of minutes of saved ActiGraph data per child is shown in table 13. Using cuts offs for sedentary behaviour defined previously by Reilly(51) for pre-school children, the number and % of minutes classified as sedentary or active during the measurement period are shown (table 13). The median proportion of minutes spent in sedentary behaviours was 89% (interquartile range 76.4-93.5%).

To further define activity, ActiGraph cut offs used in a longitudinal study of pre-school children(32) were used to differentiate activity categories. This included cut offs for Light, Moderate and Vigorous physical activity as validated by Puyau et al (50). Individual child data are shown in tables 14 and 15. The majority of active minutes were spent in light intensity activity (1100 – 2999 counts per minute). No child had any minutes categorised by their ActiGraph counts as vigorous. Children with any proportion of time spent outdoors during their monitoring period (n=13) spent less minutes sedentary than those children (n=17) with indoor time only. The median % ActiGraph defined sedentary minutes for children with any period of outdoor time was 57.6% vs. 93.6% for those with all monitoring undertaken indoors (Mann Whitney test p=0.0001), figure 7.

### *3.6.1 ActiGraph results: tables and figures*

| | N0001 | N0002 | N0003 | N0004 | N0005 | N0006 | N0007 | N0008 | N0009 | N0010 | N0011 | N0012 | N0013 | N0014 | N0015 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sedentary (<1100 counts per minute)** | | | | | | | | | | | | | | | |
| Total sedentary Minutes | 54 | 54 | 53 | 52 | 17 | 30 | 59 | 60 | 70 | 34 | 66 | 50 | 56 | 51 | 51 |
| **% Total Minutes** | **93.1** | **96.4** | **91.4** | **89.7** | **30.9** | **50.8** | **96.7** | **98.4** | **84.3** | **54.8** | **98.5** | **80.6** | **90.3** | **75.0** | **85.0** |
| **Active (≥1100 counts per minute)** | | | | | | | | | | | | | | | |
| Total Active Minutes | 4 | 2 | 5 | 6 | 38 | 29 | 2 | 1 | 13 | 28 | 1 | 12 | 6 | 17 | 9 |
| **% Total Minutes** | **6.9** | **3.6** | **8.6** | **10.3** | **69.1** | **49.2** | **3.3** | **1.6** | **15.7** | **45.2** | **1.5** | **19.4** | **9.7** | **25.0** | **15.0** |
| **Total Minutes** | 58 | 56 | 58 | 58 | 55 | 59 | 61 | 61 | 83 | 62 | 67 | 62 | 62 | 68 | 60 |

| | N0016 | N0017 | N0018 | N0019 | N0020 | N0021 | N0023 | N0024 | N0025 | N0027 | N0028 | N0029 | N0030 | N0031 | N0032 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sedentary (<1100 counts per minute)** | | | | | | | | | | | | | | | |
| Total sedentary Minutes | 53 | 58 | 58 | 59 | 51 | 34 | 48 | 38 | 58 | 65 | 58 | 23 | 58 | 76 | 63 |
| **% Total Minutes** | **88.3** | **93.5** | **95.1** | **96.7** | **83.6** | **57.6** | **56.5** | **52.8** | **93.5** | **98.5** | **87.9** | **39.0** | **92.1** | **84.4** | **92.6** |
| **Active (≥1100 counts per minute)** | | | | | | | | | | | | | | | |
| Total Active Minutes | 7 | 4 | 3 | 2 | 10 | 25 | 37 | 34 | 4 | 1 | 8 | 36 | 5 | 14 | 5 |
| **% Total Minutes** | **11.7** | **6.5** | **4.9** | **3.3** | **16.4** | **42.4** | **43.5** | **47.2** | **6.5** | **1.5** | **12.1** | **61.0** | **7.9** | **15.6** | **7.4** |
| **Total Minutes** | 60 | 62 | 61 | 61 | 61 | 59 | 85 | 72 | 62 | 66 | 66 | 59 | 63 | 90 | 68 |

**Table 13 ActiGraph defined sedentary behaviour (Reilly 2003 cut offs), child N0001-N0032**

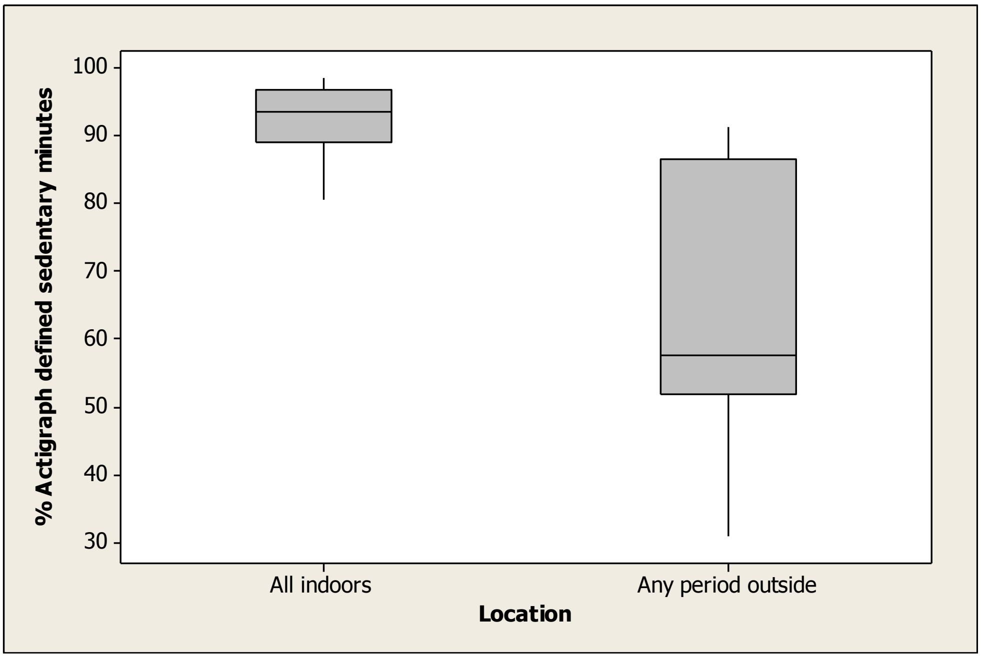
| | N0001 | N0002 | N0003 | N0004 | N0005 | N0006 | N0007 | N0008 | N0009 | N0010 | N0011 | N0012 | N0013 | N0014 | N0015 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total minutes measured | 58 | 56 | 58 | 58 | 55 | 59 | 61 | 61 | 83 | 62 | 67 | 62 | 62 | 68 | 60 |
| **Sedentary (<1100 counts per minute)** | | | | | | | | | | | | | | | |
| Total sedentary minutes | 54 | 54 | 53 | 52 | 17 | 30 | 59 | 60 | 70 | 34 | 66 | 50 | 56 | 51 | 51 |
| % Total minutes | 93.1 | 96.4 | 91.4 | 89.7 | 30.9 | 50.8 | 96.7 | 98.4 | 84.3 | 54.8 | 98.5 | 80.6 | 90.3 | 75.0 | 85.0 |
| **Light (1100 to <3200 counts per minute)** | | | | | | | | | | | | | | | |
| Total Light minutes | 4 | 2 | 5 | 5 | 28 | 19 | 2 | 1 | 12 | 22 | 1 | 11 | 5 | 17 | 9 |
| % Total minutes | 6.9 | 3.6 | 8.6 | 8.6 | 50.9 | 32.2 | 3.3 | 1.6 | 14.5 | 35.5 | 1.5 | 17.7 | 8.1 | 25.0 | 15.0 |
| **Moderate (3200 to <8200 counts per minute)** | | | | | | | | | | | | | | | |
| Total Moderate minutes | 0 | 0 | 0 | 1 | 10 | 9 | 0 | 0 | 1 | 6 | 0 | 1 | 1 | 0 | 0 |
| % Total minutes | 0.0 | 0.0 | 0.0 | 1.7 | 18.2 | 15.3 | 0.0 | 0.0 | 1.2 | 9.7 | 0.0 | 1.6 | 1.6 | 0.0 | 0.0 |
| **Vigorous (≥8200 counts per minute)** | | | | | | | | | | | | | | | |
| Total Vigorous minutes | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| % Total minutes | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Puyau 2002 definition of sedentary (<800 counts per minute)** | | | | | | | | | | | | | | | |
| Total sedentary minutes | 52 | 53 | 53 | 51 | 13 | 23 | 59 | 58 | 62 | 29 | 65 | 42 | 55 | 43 | 49 |
| % Total minutes | 89.7 | 94.6 | 91.4 | 87.9 | 23.6 | 39.0 | 96.7 | 95.1 | 74.7 | 46.8 | 97.0 | 67.7 | 88.7 | 63.2 | 81.7 |

**Table 14 ActiGraph defined activity intensity, Reilly 2003 and Puyau 2002 cut offs, child N0001-N0015**

| | N0016 | N0017 | N0018 | N0019 | N0020 | N0021 | N0023 | N0024 | N0025 | N0027 | N0028 | N0029 | N0030 | N0031 | N0032 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total minutes measured | 60 | 62 | 61 | 61 | 61 | 59 | 85 | 72 | 62 | 66 | 66 | 59 | 63 | 90 | 68 |
| **Sedentary (<1100 counts per minute)** | | | | | | | | | | | | | | | |
| Total sedentary minutes | 53 | 58 | 58 | 59 | 51 | 34 | 48 | 38 | 58 | 65 | 58 | 23 | 58 | 76 | 63 |
| % Total Minutes | 88.3 | 93.5 | 95.1 | 96.7 | 83.6 | 57.6 | 56.5 | 52.8 | 93.5 | 98.5 | 87.9 | 39.0 | 92.1 | 84.4 | 92.6 |
| **Light (1100 to <3200 counts per minute)** | | | | | | | | | | | | | | | |
| Total Light minutes | 7 | 4 | 3 | 2 | 9 | 24 | 31 | 29 | 2 | 1 | 8 | 33 | 5 | 14 | 5 |
| % Total minutes | 11.7 | 6.5 | 4.9 | 3.3 | 14.8 | 40.7 | 36.5 | 40.3 | 3.2 | 1.5 | 12.1 | 55.9 | 7.9 | 15.6 | 7.4 |
| **Moderate (3200 to <8200 counts per minute)** | | | | | | | | | | | | | | | |
| Total Moderate minutes | 0 | 0 | 0 | 0 | 1 | 1 | 6 | 5 | 2 | 0 | 0 | 3 | 0 | 0 | 0 |
| % Total minutes | 0.0 | 0.0 | 0.0 | 0.0 | 1.6 | 1.7 | 7.1 | 6.9 | 3.2 | 0.0 | 0.0 | 5.1 | 0.0 | 0.0 | 0.0 |
| **Vigorous (≥8200 counts per minute)** | | | | | | | | | | | | | | | |
| Total Vigorous Minutes | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| % Total Minutes | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Puyau definition of Sedentary (<800 counts per minute)** | | | | | | | | | | | | | | | |
| Total sedentary Minutes | 50 | 56 | 55 | 57 | 48 | 23 | 37 | 32 | 57 | 63 | 55 | 15 | 55 | 67 | 59 |
| % Total Minutes | 83.3 | 90.3 | 90.2 | 93.4 | 78.7 | 39.0 | 43.5 | 44.4 | 91.9 | 95.5 | 83.3 | 25.4 | 87.3 | 74.4 | 86.8 |

**Table 15 ActiGraph defined activity intensity, Reilly 2003 and Puyau 2002 cut offs, child N0016-N0032**

**Figure 7 Boxplot of % Actigraph defined sedentary minutes according to location of data collection (indoor or any period outdoor)**




Sedentary minutes were defined according to the definition of Reilly et al(51). Box plots represent median, interquartile and total range of % sedentary minutes according to whether data collection was entirely indoors or had any period of time outdoors. Mann Whitney test, p = 0.0001

## 3.7 Validation of *activ*PAL™ against video observation

The *activ*PAL™ output for the total monitoring period for all children with a complete data set is shown in table 16. This output encompasses all on screen seconds (on which direct observation comparisons were made) and off screen seconds where activity could not be visualised. Table 17 is the *activ*PAL™ output for all on screen seconds only, for each child. The median on screen time spent in each *activ*PAL™ output category was 43.5% (IQR 30.2-50.9) for sit/lie, 41.2% (IQR 26.0-53.2) for stand and 12.2% (IQR 7-21.6) for walk. The *activ*PAL™ derived step count was not validated as part of this study.

Cumulative *activ*PAL™ data for the 97,750 on screen seconds on which comparisons with direct observation data were based categorised 40,755 (42%) of seconds as sit/lie, 41,268 (42%) as stand, and 15,727 (16%) as walking. Comparison of the direct observation data with *activ*PAL™ output is shown in figures 8 and 9. The proportion of seconds identified as walking by direct observation correlated with the proportion of seconds identified as walking by the *activ*PAL™ ($r = 0.99$, $p <0.001$) represented graphically in figure 10. The *activ*PAL™ output for stand correlated significantly with direct observation stand ($r = 0.94$, $p <0.001$), figure 11. However, the *activ*PAL™ tended to overestimate time spent standing, and the magnitude of this bias is demonstrated in the Bland Altman plot direct observation ‘stand’ seconds vs. *activ*PAL™ output ‘stand’ seconds, figure 14. Conversely *activ*PAL™ output for sit/lie correlated significantly with direct observation sit/lie ($r = 0.95$, $p <0.001$) but tended to underestimate total number of seconds spent sitting/lying (figures 12 and 13). The Bland Altman plot is shown in figure 14.

Sensitivity, specificity and positive predictive values (PPVs) for the *activ*PAL™ outputs of sit/lie, stand and walk are shown for each child in tables 18 to 23. Because the video observation data also has ‘other’ as a category, the sensitivity, specificity and PPVs were calculated both including and excluding all seconds categorised in direct observation as ‘other’ as described in Methods.

Cumulating the data from all 30 children (and including all 'other' seconds), 39257 seconds were correctly identified as sit/lie (true positives), 6025 seconds were not identified as sit/lie when they should have been (false negatives), 50,970 seconds correctly identified as not sit/lie (true negatives) and 1498 seconds were identified as sit/lie when they were not (false positives). Thus the overall sensitivity for *activ*PAL™ sit lie was 86.7%, specificity 97.1% and PPV 96.3%. For individual children, the median sensitivity for *activ*PAL™ sit/lie was 92.8% (interquartile range 76.1-97.4%, minimum 44.7%), specificity 97.3% (IQR 94.9-99.2%, minimum 88.3%), and positive predictive value 97.0% (IQR 91.5-99.1%, minimum 83.8%).

Excluding 'other' seconds, the results were as follows: overall (cumulative) sensitivity 86.7% (unchanged as 'other' seconds were never considered true positives or false negatives), specificity 99.2%, PPV 99.0%. For individual children, the median specificity increased to 99.5% (IQR 98.9-99.9%, minimum 96%) and median positive predictive value 99.4% (IQR 98.4-99.8, minimum 91%).

The cumulative overall sensitivity for *activ*PAL™ stand was 91.8%, specificity 84.3 % and PPV 75.8%. For individual children, the median sensitivity for *activ*PAL™ stand was 91.8% (interquartile range 82.6-96.6%, minimum 70.0%), specificity 86.5% (IQR 75.6-91.7%, minimum 55.9%), and positive predictive value 70.4% (IQR 61.2-83.5%, minimum 40.2%). As before, excluding 'other' seconds, overall specificity was 85.9%, PPV 78.6%. For individual children, the median specificity was 87.9% (IQR 78.1-94.0%, minimum 56.4%) and median positive predictive value 72.4% (IQR 63.7-86.9, minimum 42.7%).

The cumulative overall sensitivity for *activ*PAL™ walk was 80.3%, specificity 95.9 % and PPV 78.4%. For individual children, the median sensitivity for *activ*PAL™ walk was 77.9% (interquartile range 69.1-86.9%, minimum 46.9%), specificity 96.5% (IQR 93.7-97.9%, minimum 83.5%), and positive predictive value 73.4% (IQR 68.0-85.1%, minimum 47.9%). As for sit/lie and stand, excluding 'other' seconds, overall specificity for walk was 96.3%, PPV 80.8%. For individual children, the median specificity was 96.7% (IQR 94.4-98.1%, minimum 84.8%) and median positive predictive value 77.6% (IQR 69.2-87.0, minimum 52.1%).

Most postural misclassifications were as a result of sitting being identified by the *activ*PAL™ as standing. It was noted by the author when reviewing the filmed records that this occurred in particular when children sat at the front of their chair with thighs hanging down and knees toward the floor, or over the side of a chair with one leg in a 'normal' sitting position with thigh horizontal, knee bent at 90 degrees, and foot on floor and the other leg over the side of the chair with thigh hanging down (see figure 15). An example corresponding *activ*PAL™ (and DynaPort MicroMod) output for a child is shown. This resulted in an overestimation of standing time, and underestimation of sitting. Occasionally, standing was misclassified as sitting. An example of this is shown in figure 16. As per diagram, the child stood with one leg straight and one bent at the knee with the foot resting on top of the other foot. This changed the angle of the right thigh, and was interpreted by the *activ*PAL™ as sit/lie.

The *activ*PAL™ has no unknown category for output, and therefore all data are categorised as either sit/lie, stand or walk. The *activ*PAL™ output for all children (n=6) with >5% of the direct observation period in postures categorised as 'other' (crawl, crouch, kneel up and other) is shown in tables 24 and 25. In these children, kneel up was most often classified by the *activ*PAL™ as stand (although for child N0028 the predominant output was for sit/lie), and crouch as sit/lie. Crawl was categorised by a combination of stand and walk output, and rarely by the output of sit/lie. The 'other' (requiring diagram) seconds were categorised as a combination of all three outputs, reflecting the heterogeneity of posture and activity comprising this group. Example diagrams and outputs are shown in figures 17 to 21.

Two children in the study had time spent during the observation period on tricycles during outdoor play (N0021 and N0029). The Minitab summary of direct observation and *activ*PAL™ output is shown in table 26. Sitting peddling on their tricycles was captured by *activ*PAL™ as predominantly sit/lie.

### *3.7.1 activPAL$^{TM}$ validation results: tables and figures*

| | N0001 | N0002 | N0003 | N0004 | N0005 | N0006 | N0007 | N0008 | N0009 | N0010 | N0011 | N0012 | N0013 | N0014 | N0015 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***activ*PAL™ output category (seconds)** | | | | | | | | | | | | | | | |
| sit/lie | 1596 | 972 | 1416 | 1425 | 1385 | 1439 | 184 | 94 | 2701 | 1026 | 3062 | 1326 | 1660 | 1555 | 818 |
| Stand | 1587 | 2019 | 1658 | 1555 | 884 | 785 | 3182 | 3176 | 1231 | 1218 | 670 | 1973 | 1548 | 1060 | 2125 |
| Walk | 258 | 360 | 360 | 449 | 1027 | 1286 | 255 | 351 | 889 | 1417 | 188 | 332 | 393 | 1410 | 615 |
| Total | 3441 | 3351 | 3434 | 3429 | 3296 | 3510 | 3621 | 3621 | 4821 | 3661 | 3920 | 3631 | 3601 | 4025 | 3558 |
| ***activ*PAL™ % total monitored time** | | | | | | | | | | | | | | | |
| sit/lie | 46.4 | 29.0 | 41.2 | 41.6 | 42.0 | 41.0 | 5.1 | 2.6 | 56.0 | 28.0 | 78.1 | 36.5 | 46.1 | 38.6 | 23.0 |
| stand | 46.1 | 60.3 | 48.3 | 45.3 | 26.8 | 22.4 | 87.9 | 87.7 | 25.5 | 33.3 | 17.1 | 54.3 | 43.0 | 26.3 | 59.7 |
| walk | 7.5 | 10.7 | 10.5 | 13.1 | 31.2 | 36.6 | 7.0 | 9.7 | 18.4 | 38.7 | 4.8 | 9.1 | 10.9 | 35.0 | 17.3 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

| | N0016 | N0017 | N0018 | N0019 | N0020 | N0021 | N0023 | N0024 | N0025 | N0027 | N0028 | N0029 | N0030 | N0031 | N0032 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***activ*PAL™ output category (seconds)** | | | | | | | | | | | | | | | |
| sit/lie | 445 | 2899 | 1826 | 2913 | 1584 | 1070 | 2011 | 1216 | 1553 | 1373 | 1366 | 746 | 1869 | 1750 | 282 |
| stand | 2494 | 605 | 1549 | 562 | 1389 | 842 | 1701 | 1300 | 1858 | 1947 | 1951 | 960 | 1296 | 2617 | 2763 |
| walk | 609 | 165 | 244 | 146 | 649 | 1618 | 1338 | 1768 | 263 | 589 | 590 | 1812 | 560 | 987 | 921 |
| Total | 3548 | 3669 | 3619 | 3621 | 3622 | 3530 | 5050 | 4284 | 3674 | 3909 | 3907 | 3518 | 3725 | 5354 | 3966 |
| ***activ*PAL™ % total monitored time** | | | | | | | | | | | | | | | |
| sit/lie | 12.5 | 79.0 | 50.5 | 80.4 | 43.7 | 30.3 | 39.8 | 28.4 | 42.3 | 35.1 | 35.0 | 21.2 | 50.2 | 32.7 | 7.1 |
| stand | 70.3 | 16.5 | 42.8 | 15.5 | 38.3 | 23.9 | 33.7 | 30.3 | 50.6 | 49.8 | 49.9 | 27.3 | 34.8 | 48.9 | 69.7 |
| walk | 17.2 | 4.5 | 6.7 | 4.0 | 17.9 | 45.8 | 26.5 | 41.3 | 7.2 | 15.1 | 15.1 | 51.5 | 15.0 | 18.4 | 23.2 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

**Table 16 Number of seconds and % total monitored time in *activ*PAL™ output category (sit/lie, stand or walk) Child N0001-N0032**

| | N0001 | N0002 | N0003 | N0004 | N0005 | N0006 | N0007 | N0008 | N0009 | N0010 | N0011 | N0012 | N0013 | N0014 | N0015 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***activ*PAL™ output category (seconds)** | | | | | | | | | | | | | | | |
| sit/lie | 1538 | 972 | 1368 | 1330 | 826 | 1320 | 180 | 71 | 2679 | 959 | 3049 | 1257 | 1655 | 1426 | 760 |
| stand | 1489 | 1994 | 1564 | 1437 | 671 | 573 | 3178 | 3106 | 494 | 741 | 583 | 1822 | 1535 | 478 | 1931 |
| walk | 235 | 353 | 216 | 259 | 855 | 1092 | 248 | 254 | 676 | 1063 | 119 | 303 | 388 | 759 | 481 |
| total | 3262 | 3319 | 3148 | 3026 | 2352 | 2985 | 3606 | 3431 | 3849 | 2763 | 3751 | 3382 | 3578 | 2663 | 3172 |
| **% time spent in *activ*PAL™ category** | | | | | | | | | | | | | | | |
| sit/lie | 47.1 | 29.3 | 43.5 | 44.0 | 35.1 | 44.2 | 5.0 | 2.1 | 69.6 | 34.7 | 81.3 | 37.2 | 46.3 | 53.5 | 24.0 |
| stand | 45.6 | 60.1 | 49.7 | 47.5 | 28.5 | 19.2 | 88.1 | 90.5 | 12.8 | 26.8 | 15.5 | 53.9 | 42.9 | 17.9 | 60.9 |
| walk | 7.2 | 10.6 | 6.9 | 8.6 | 36.4 | 36.6 | 6.9 | 7.4 | 17.6 | 38.5 | 3.2 | 9.0 | 10.8 | 28.5 | 15.2 |
| total | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

| | N0016 | N0017 | N0018 | N0019 | N0020 | N0021 | N0023 | N0024 | N0025 | N0027 | N0028 | N0029 | N0030 | N0031 | N0032 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***activ*PAL™ output category (seconds)** | | | | | | | | | | | | | | | |
| sit/lie | 433 | 2825 | 1811 | 2867 | 1559 | 902 | 1932 | 1155 | 1459 | 857 | 1277 | 652 | 1763 | 1592 | 281 |
| stand | 2342 | 401 | 1316 | 482 | 1347 | 692 | 897 | 754 | 1701 | 1528 | 1746 | 848 | 1148 | 1819 | 2651 |
| walk | 419 | 140 | 207 | 81 | 621 | 1397 | 440 | 1016 | 193 | 428 | 385 | 1610 | 473 | 142 | 874 |
| total | 3194 | 3366 | 3334 | 3430 | 3527 | 2991 | 3269 | 2925 | 3353 | 2813 | 3408 | 3110 | 3384 | 3553 | 3806 |
| **% time spent in *activ*PAL™ category** | | | | | | | | | | | | | | | |
| sit/lie | 13.6 | 83.9 | 54.3 | 83.6 | 44.2 | 30.2 | 59.1 | 39.5 | 43.5 | 30.5 | 37.5 | 21.0 | 52.1 | 44.8 | 7.4 |
| stand | 73.3 | 11.9 | 39.5 | 14.1 | 38.2 | 23.1 | 27.4 | 25.8 | 50.7 | 54.3 | 51.2 | 27.3 | 33.9 | 51.2 | 69.7 |
| walk | 13.1 | 4.2 | 6.2 | 2.4 | 17.6 | 46.7 | 13.5 | 34.7 | 5.8 | 15.2 | 11.3 | 51.8 | 14.0 | 4.0 | 23.0 |
| total | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

**Table 17 Number of seconds and % total time in *activ*PAL™ output category (sit/lie, stand or walk) for 'On Screen' seconds only. Child N0001-N0032**

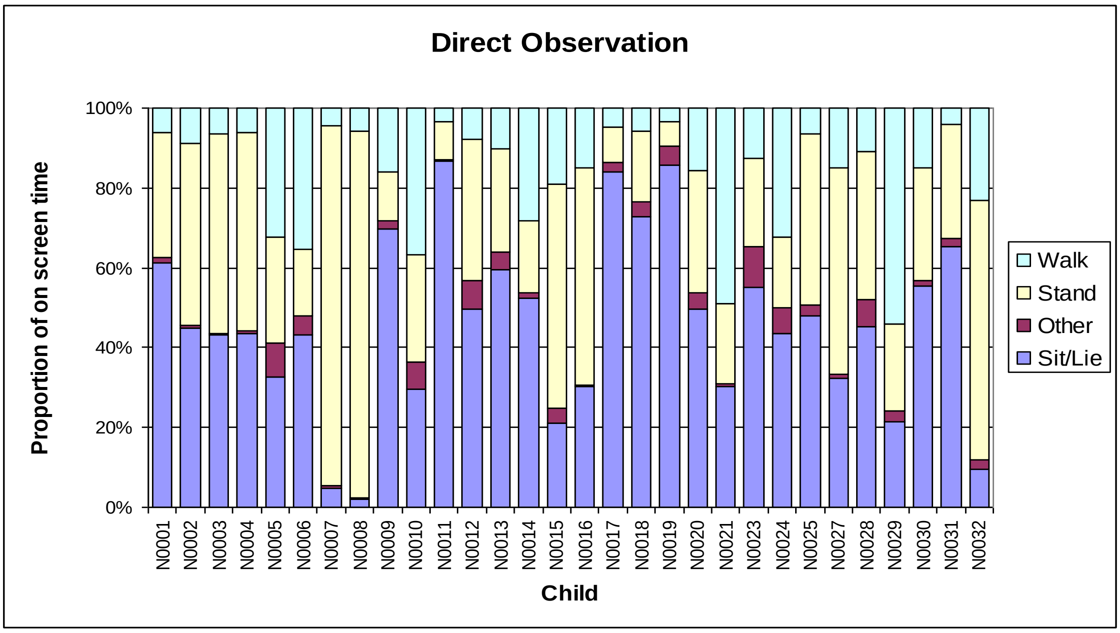



**Figure 8. Proportion of on screen time according to direct observation category for each child**

Direct observation 'Walk' includes walk, run, jump, skip, and dance. 'Other' includes crouch, kneel up, crawl and 'other'. Sit/lie includes sit, lie and peddle.

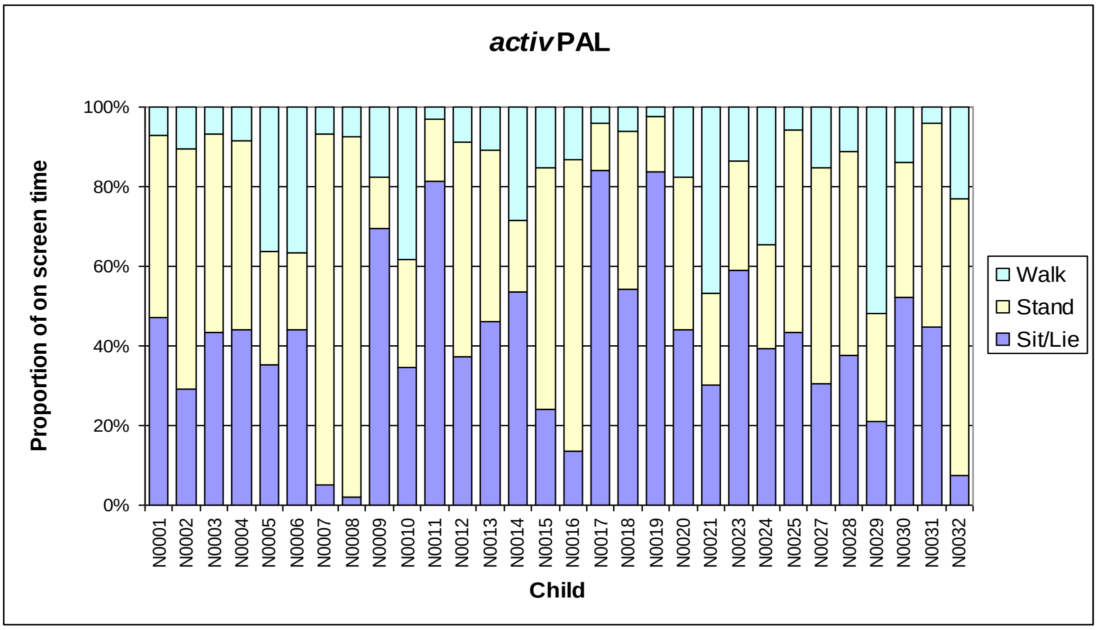



**Figure 9. Proportion of on screen time according to *activ*PAL™ output category for each child (walk, stand, sit/lie)**

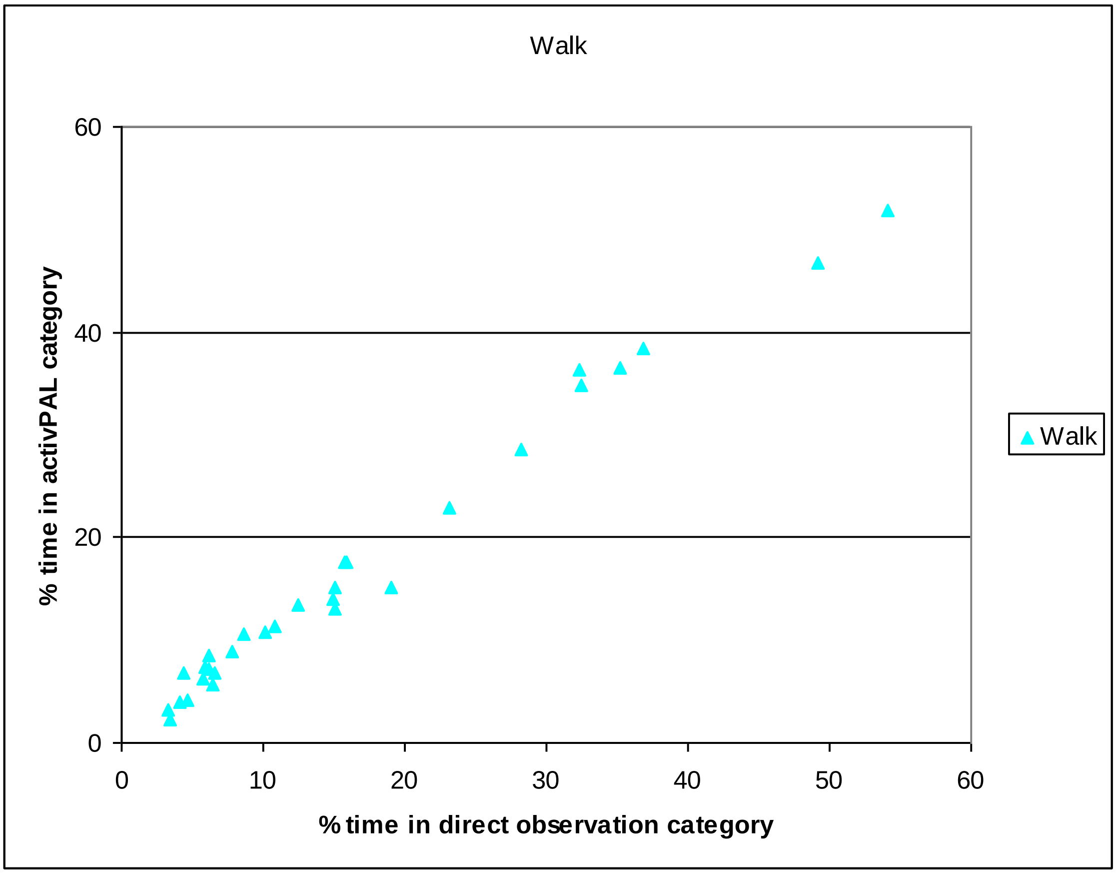



**Figure 10. Proportion of on screen time spent in *activ*PAL™ walk against proportion of time spend in direct observation category walk**

Each child is represented by an individual data point, r=0.99, p<0.001. Direct observation walk included walk, run, dance, jump and skip.

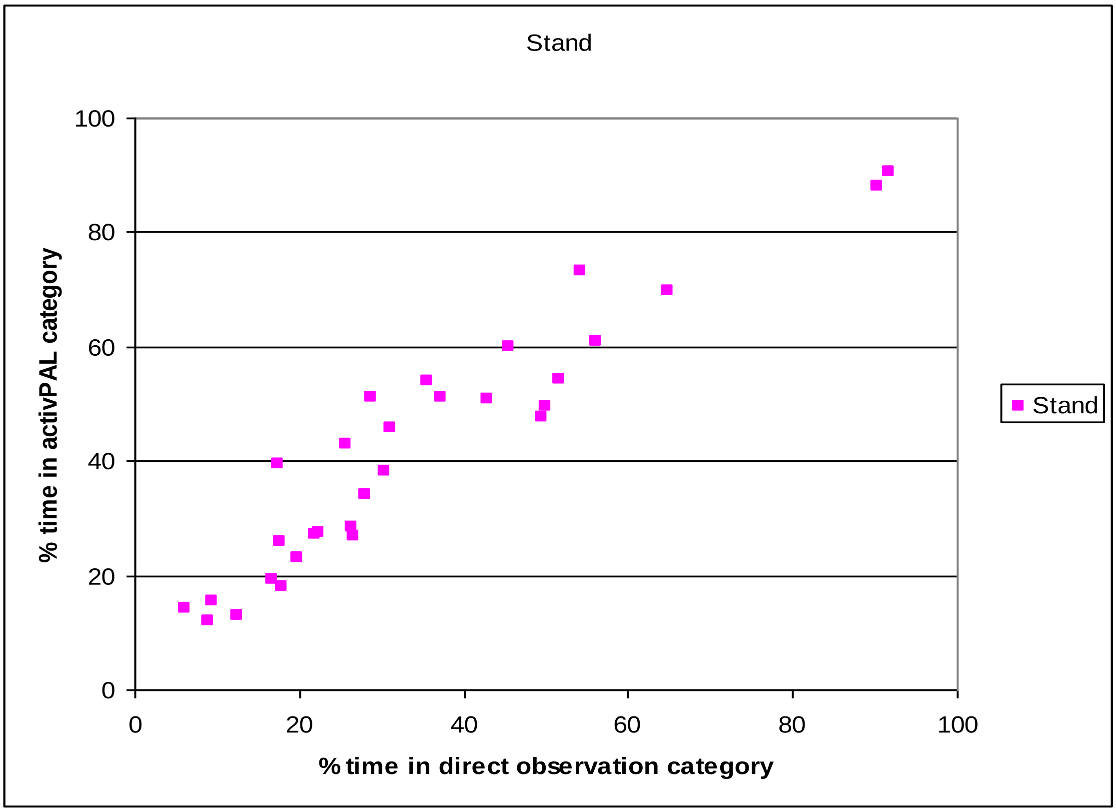



**Figure 11. Proportion of on screen time in *activ*PAL$^{TM}$ category stand against proportion of time in direct observation category stand.**

Each child is represented by an individual data point, r = 0.94, p<0.001

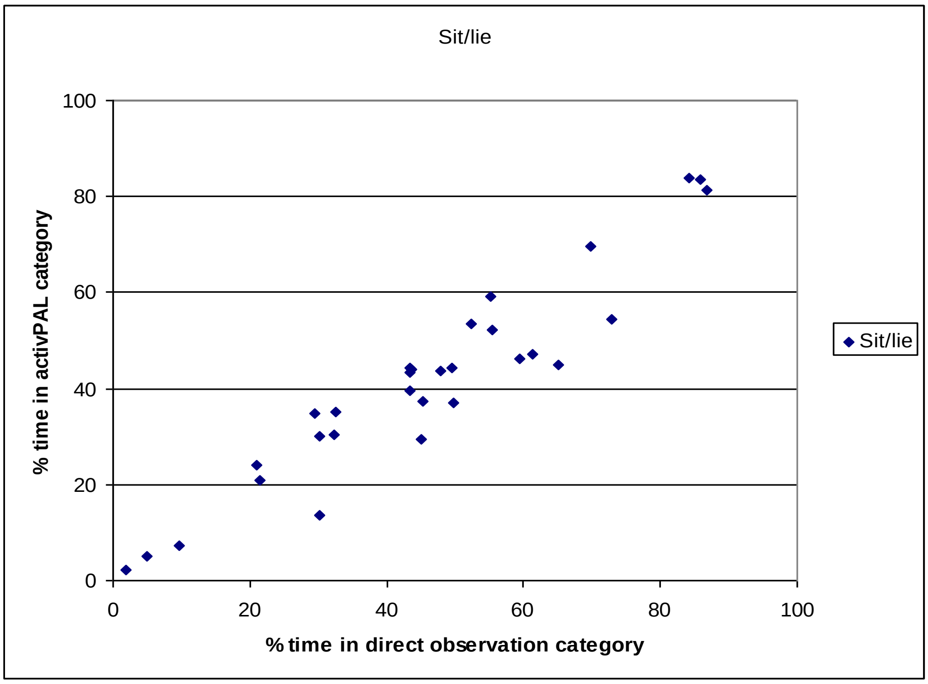



**Figure 12. Proportion of on screen time in *activ*PAL™ category sit/lie against proportion of time in direct observation categories sit and lie**

Each child is represented by an individual data point, r = 0.95, p<0.001

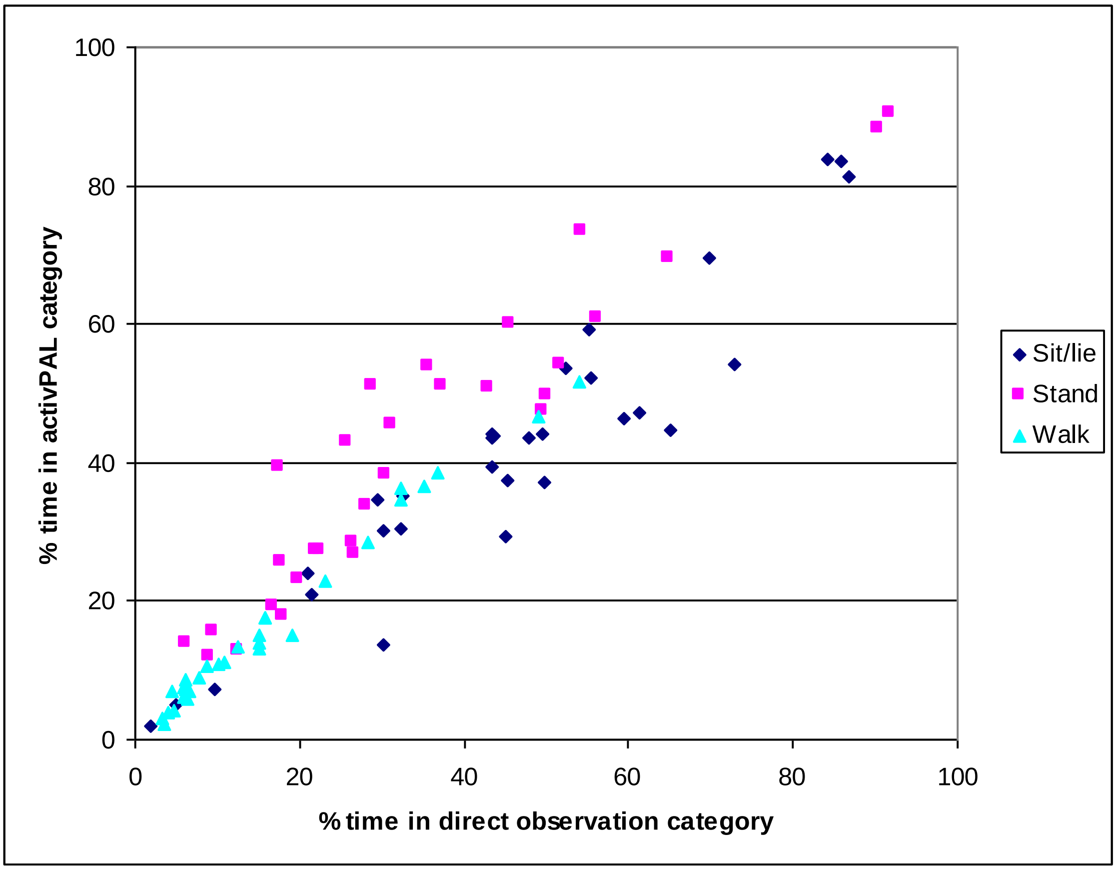
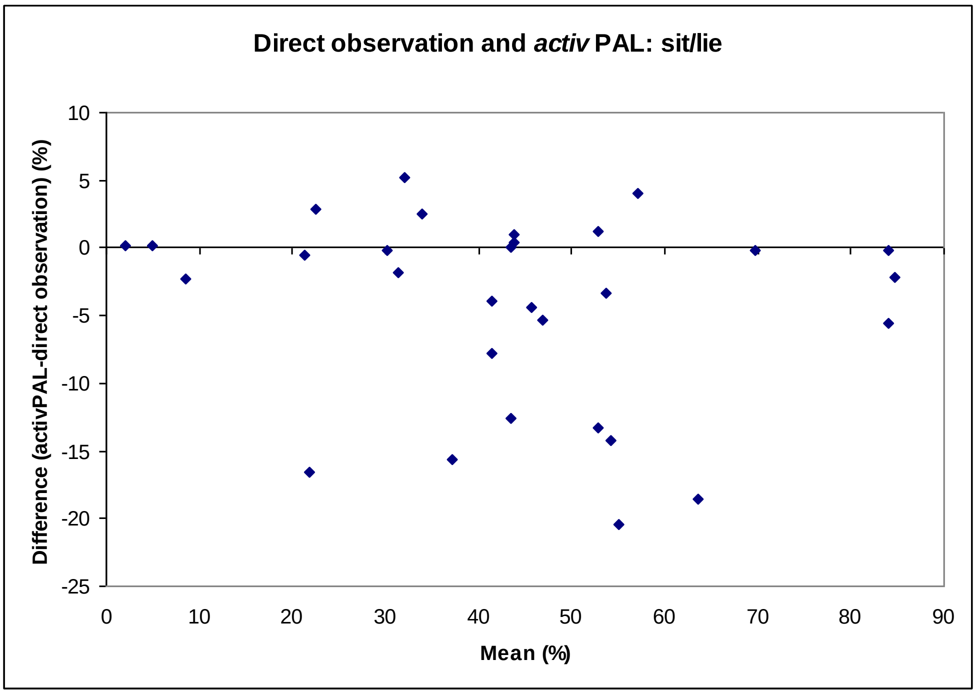



**Figure 13. Overall summary comparing proportion of time in *activ*PAL[TM] category with direct observation category**

Each child is represented by a data point for sit/lie, stand and walk. Correlation coefficients as previously quoted.



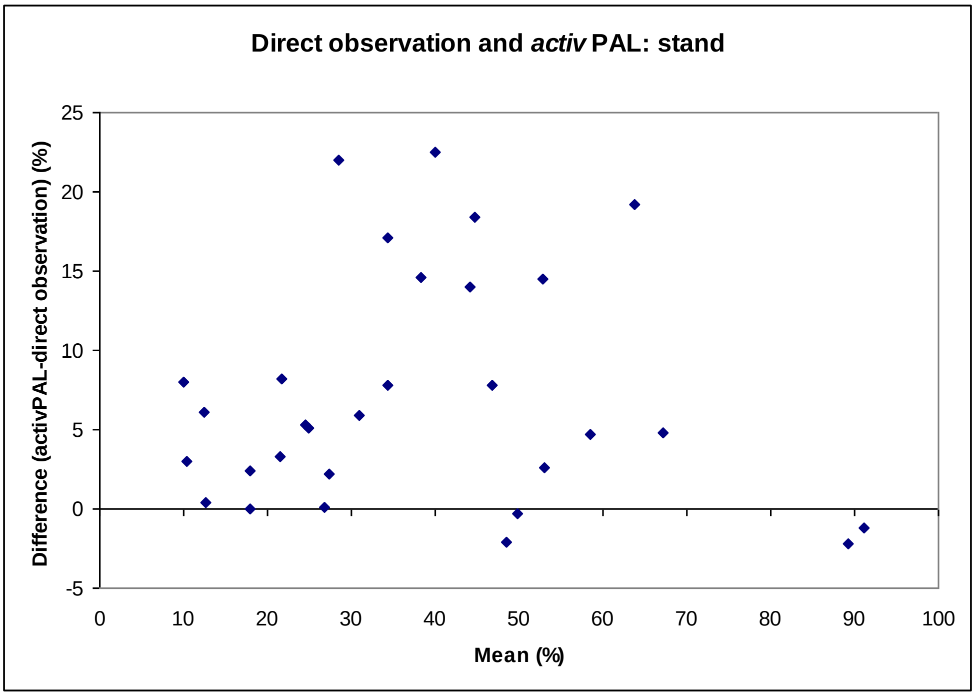




**Figure 14. Bland Altman plots for *activ*PAL™ and direct observation**

Bland Altman plots for proportion on screen seconds in direct observation sit + lie and *activ*PAL™ sit/lie and *activ*PAL™ stand as shown. Each child is represented by an individual data point. *activ*PAL™ tended to underestimate time sitting (bias -4.4%, 95% limit of agreement -18.4% to 9.6%, r= -0.17, p=0.37). Conversely time detected by the *activ*PAL™ as stand tended to be overestimated (bias 7.1%, 95% limit of agreement -7.2% to 21.5%, r=-0.03, p=0.88)

| | N0001 | N0002 | N0003 | N0004 | N0005 | N0006 | N0007 | N0008 | N0009 | N0010 | N0011 | N0012 | N0013 | N0014 | N0015 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| True positives | 1513 | 947 | 1365 | 1318 | 745 | 1225 | 174 | 63 | 2618 | 804 | 3028 | 1218 | 1650 | 1386 | 637 |
| False negatives | 489 | 545 | 0 | 0 | 21 | 67 | 1 | 3 | 68 | 10 | 231 | 466 | 479 | 6 | 32 |
| True negatives | 1235 | 1802 | 1780 | 1696 | 1505 | 1598 | 3425 | 3357 | 1102 | 1794 | 471 | 1659 | 1444 | 1231 | 2380 |
| False positives | 25 | 25 | 3 | 12 | 81 | 95 | 6 | 8 | 61 | 155 | 21 | 39 | 5 | 40 | 123 |
| Total (seconds) | 3262 | 3319 | 3148 | 3026 | 2352 | 2985 | 3606 | 3431 | 3849 | 2763 | 3751 | 3382 | 3578 | 2663 | 3172 |
| **sensitivity %** | **75.6** | **63.5** | **100.0** | **100.0** | **97.3** | **94.8** | **99.4** | **95.5** | **97.5** | **98.8** | **92.9** | **72.3** | **77.5** | **99.6** | **95.2** |
| **specificity %** | **98.0** | **98.6** | **99.8** | **99.3** | **94.9** | **94.4** | **99.8** | **99.8** | **94.8** | **92.0** | **95.7** | **97.7** | **99.7** | **96.9** | **95.1** |
| **positive predictive value %** | **98.4** | **97.4** | **99.8** | **99.1** | **90.2** | **92.8** | **96.7** | **88.7** | **97.7** | **83.8** | **99.3** | **96.9** | **99.7** | **97.2** | **83.8** |
| | | | | | | | | | | | | | | | |
| **Excluding all direct observation 'Other' seconds (i.e. excluding other, kneel up, crouch, crawl)** | | | | | | | | | | | | | | | |
| True positives | 1513 | 947 | 1365 | 1318 | 745 | 1225 | 174 | 63 | 2618 | 804 | 3028 | 1218 | 1650 | 1386 | 637 |
| False negatives | 489 | 545 | 0 | 0 | 21 | 67 | 1 | 3 | 68 | 10 | 231 | 466 | 479 | 6 | 32 |
| True negatives | 1215 | 1795 | 1779 | 1682 | 1369 | 1491 | 3414 | 3347 | 1083 | 1729 | 461 | 1464 | 1288 | 1224 | 2374 |
| False positives | 1 | 6 | 0 | 6 | 12 | 61 | 1 | 0 | 6 | 28 | 19 | 2 | 1 | 7 | 12 |
| Total (seconds) | 3218 | 3293 | 3144 | 3006 | 2147 | 2844 | 3590 | 3413 | 3775 | 2571 | 3739 | 3150 | 3418 | 2623 | 3055 |
| **sensitivity %** | **75.6** | **63.5** | **100.0** | **100.0** | **97.3** | **94.8** | **99.4** | **95.5** | **97.5** | **98.8** | **92.9** | **72.3** | **77.5** | **99.6** | **95.2** |
| **specificity %** | **99.9** | **99.7** | **100.0** | **99.6** | **99.1** | **96.1** | **100.0** | **100.0** | **99.4** | **98.4** | **96.0** | **99.9** | **99.9** | **99.4** | **99.5** |
| **positive predictive value %** | **99.9** | **99.4** | **100.0** | **99.5** | **98.4** | **95.3** | **99.4** | **100.0** | **99.8** | **96.6** | **99.4** | **99.8** | **99.9** | **99.5** | **98.2** |

**Table 18 *activ*PAL$^{TM}$ sit/lie output against direct observation, child N0001-N0015**

| | N0016 | N0017 | N0018 | N0019 | N0020 | N0021 | N0023 | N0024 | N0025 | N0027 | N0028 | N0029 | N0030 | N0031 | N0032 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| True positives | 430 | 2809 | 1759 | 2845 | 1462 | 840 | 1760 | 1114 | 1446 | 828 | 1127 | 565 | 1742 | 1585 | 254 |
| False negatives | 533 | 23 | 670 | 97 | 284 | 66 | 42 | 157 | 159 | 79 | 417 | 104 | 133 | 731 | 112 |
| True negatives | 2228 | 518 | 853 | 466 | 1684 | 2023 | 1295 | 1613 | 1735 | 1877 | 1714 | 2354 | 1488 | 1230 | 3413 |
| False positives | 3 | 16 | 52 | 22 | 97 | 62 | 172 | 41 | 13 | 29 | 150 | 87 | 21 | 7 | 27 |
| Total (seconds) | 3194 | 3366 | 3334 | 3430 | 3527 | 2991 | 3269 | 2925 | 3353 | 2813 | 3408 | 3110 | 3384 | 3553 | 3806 |
| **sensitivity %** | **44.7** | **99.2** | **72.4** | **96.7** | **83.7** | **92.7** | **97.7** | **87.6** | **90.1** | **91.3** | **73.0** | **84.5** | **92.9** | **68.4** | **69.4** |
| **specificity %** | **99.9** | **97.0** | **94.3** | **95.5** | **94.6** | **97.0** | **88.3** | **97.5** | **99.3** | **98.5** | **92.0** | **96.4** | **98.6** | **99.4** | **99.2** |
| **positive predictive value %** | **99.3** | **99.4** | **97.1** | **99.2** | **93.8** | **93.1** | **91.1** | **96.5** | **99.1** | **96.6** | **88.3** | **86.7** | **98.8** | **99.6** | **90.4** |
| | | | | | | | | | | | | | | | |
| **Excluding all direct observation 'Other' seconds (i.e. excluding other, kneel up, crouch, crawl)** | | | | | | | | | | | | | | | |
| True positives | 430 | 2809 | 1759 | 2845 | 1462 | 840 | 1760 | 1114 | 1446 | 828 | 1127 | 565 | 1742 | 1585 | 254 |
| False negatives | 533 | 23 | 670 | 97 | 284 | 66 | 42 | 157 | 159 | 79 | 417 | 104 | 133 | 731 | 112 |
| True negatives | 2209 | 454 | 775 | 322 | 1612 | 2015 | 1107 | 1448 | 1652 | 1856 | 1636 | 2308 | 1446 | 1161 | 3346 |
| False positives | 3 | 2 | 3 | 6 | 16 | 47 | 32 | 14 | 4 | 22 | 1 | 56 | 11 | 3 | 4 |
| Total (seconds) | 3175 | 3288 | 3207 | 3270 | 3374 | 2968 | 2941 | 2733 | 3261 | 2785 | 3181 | 3033 | 3332 | 3480 | 3716 |
| **sensitivity %** | **44.7** | **99.2** | **72.4** | **96.7** | **83.7** | **92.7** | **97.7** | **87.6** | **90.1** | **91.3** | **73.0** | **84.5** | **92.9** | **68.4** | **69.4** |
| **specificity %** | **99.9** | **99.6** | **99.6** | **98.2** | **99.0** | **97.7** | **97.2** | **99.0** | **99.8** | **98.8** | **99.9** | **97.6** | **99.2** | **99.7** | **99.9** |
| **positive predictive value %** | **99.3** | **99.9** | **99.8** | **99.8** | **98.9** | **94.7** | **98.2** | **98.8** | **99.7** | **97.4** | **99.9** | **91.0** | **99.4** | **99.8** | **98.4** |

**Table 19 *activ*PAL$^{TM}$ sit/lie output against direct observation, child N0016-N0032**

| | N0001 | N0002 | N0003 | N0004 | N0005 | N0006 | N0007 | N0008 | N0009 | N0010 | N0011 | N0012 | N0013 | N0014 | N0015 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| True positives | 982 | 1419 | 1544 | 1426 | 530 | 352 | 3141 | 3071 | 344 | 581 | 320 | 1148 | 870 | 415 | 1732 |
| False negatives | 31 | 94 | 28 | 75 | 90 | 149 | 115 | 76 | 133 | 158 | 36 | 53 | 54 | 63 | 51 |
| True negatives | 1742 | 1231 | 1556 | 1514 | 1591 | 2263 | 313 | 249 | 3222 | 1864 | 3132 | 1507 | 1989 | 2122 | 1190 |
| False positives | 507 | 575 | 20 | 11 | 141 | 221 | 37 | 35 | 150 | 160 | 263 | 674 | 665 | 63 | 199 |
| Total (seconds) | 3262 | 3319 | 3148 | 3026 | 2352 | 2985 | 3606 | 3431 | 3849 | 2763 | 3751 | 3382 | 3578 | 2663 | 3172 |
| **Sensitivity %** | **96.9** | **93.8** | **98.2** | **95.0** | **85.5** | **70.3** | **96.5** | **97.6** | **72.1** | **78.6** | **89.9** | **95.6** | **94.2** | **86.8** | **97.1** |
| **Specificity %** | **77.5** | **68.2** | **98.7** | **99.3** | **91.9** | **91.1** | **89.4** | **87.7** | **95.6** | **92.1** | **92.3** | **69.1** | **74.9** | **97.1** | **85.7** |
| **Positive predictive value %** | **66.0** | **71.2** | **98.7** | **99.2** | **79.0** | **61.4** | **98.8** | **98.9** | **69.6** | **78.4** | **54.9** | **63.0** | **56.7** | **86.8** | **89.7** |
| | | | | | | | | | | | | | | | |
| **Excluding all direct observation 'Other' seconds (i.e. excluding other, kneel up, crouch, crawl)** | | | | | | | | | | | | | | | |
| True positives | 982 | 1419 | 1544 | 1426 | 530 | 352 | 3141 | 3071 | 344 | 581 | 320 | 1148 | 870 | 415 | 1732 |
| False negatives | 31 | 94 | 28 | 75 | 90 | 149 | 115 | 76 | 133 | 158 | 36 | 53 | 54 | 63 | 51 |
| True negatives | 1712 | 1210 | 1553 | 1500 | 1469 | 2206 | 298 | 236 | 3156 | 1707 | 3130 | 1444 | 1978 | 2087 | 1078 |
| False positives | 493 | 570 | 19 | 5 | 58 | 137 | 36 | 30 | 142 | 125 | 253 | 505 | 516 | 58 | 194 |
| Total (seconds) | 3218 | 3293 | 3144 | 3006 | 2147 | 2844 | 3590 | 3413 | 3775 | 2571 | 3739 | 3150 | 3418 | 2623 | 3055 |
| **Sensitivity %** | **96.9** | **93.8** | **98.2** | **95.0** | **85.5** | **70.3** | **96.5** | **97.6** | **72.1** | **78.6** | **89.9** | **95.6** | **94.2** | **86.8** | **97.1** |
| **Specificity %** | **77.6** | **68.0** | **98.8** | **99.7** | **96.2** | **94.2** | **89.2** | **88.7** | **95.7** | **93.2** | **92.5** | **74.1** | **79.3** | **97.3** | **84.7** |
| **Positive predictive value %** | **66.6** | **71.3** | **98.8** | **99.7** | **90.1** | **72.0** | **98.9** | **99.0** | **70.8** | **82.3** | **55.8** | **69.4** | **62.8** | **87.7** | **89.9** |

**Table 20 *activ*PAL™ stand output against direct observation, child N0001-N0015**

| | N0016 | N0017 | N0018 | N0019 | N0020 | N0021 | N0023 | N0024 | N0025 | N0027 | N0028 | N0029 | N0030 | N0031 | N0032 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| True positives | 1696 | 291 | 529 | 202 | 874 | 423 | 596 | 360 | 1414 | 1327 | 1171 | 503 | 838 | 982 | 2216 |
| False negatives | 33 | 10 | 55 | 7 | 197 | 169 | 134 | 154 | 25 | 128 | 97 | 179 | 112 | 37 | 252 |
| True negatives | 819 | 2955 | 1963 | 2941 | 1983 | 2130 | 2238 | 2017 | 1627 | 1157 | 1565 | 2083 | 2124 | 1697 | 903 |
| False positives | 646 | 110 | 787 | 280 | 473 | 269 | 301 | 394 | 287 | 201 | 575 | 345 | 310 | 837 | 435 |
| Total (seconds) | 3194 | 3366 | 3334 | 3430 | 3527 | 2991 | 3269 | 2925 | 3353 | 2813 | 3408 | 3110 | 3384 | 3553 | 3806 |
| **Sensitivity (%)** | **98.1** | **96.7** | **90.6** | **96.7** | **81.6** | **71.5** | **81.6** | **70.0** | **98.3** | **91.2** | **92.4** | **73.8** | **88.2** | **96.4** | **89.8** |
| **Specificity (%)** | **55.9** | **96.4** | **71.4** | **91.3** | **80.7** | **88.8** | **88.1** | **83.7** | **85.0** | **85.2** | **73.1** | **85.8** | **87.3** | **67.0** | **67.5** |
| **Positive predictive value (%)** | **72.4** | **72.6** | **40.2** | **41.9** | **64.9** | **61.1** | **66.4** | **47.7** | **83.1** | **86.8** | **67.1** | **59.3** | **73.0** | **54.0** | **83.6** |
| | | | | | | | | | | | | | | | |
| **Excluding all direct observation 'Other' seconds (i.e. excluding other, kneel up, crouch, crawl)** | | | | | | | | | | | | | | | |
| True positives | 1696 | 291 | 529 | 202 | 874 | 423 | 596 | 360 | 1414 | 1327 | 1171 | 503 | 838 | 982 | 2216 |
| False negatives | 33 | 10 | 55 | 7 | 197 | 169 | 134 | 154 | 25 | 128 | 97 | 179 | 112 | 37 | 252 |
| True negatives | 816 | 2925 | 1912 | 2925 | 1886 | 2111 | 2066 | 1934 | 1597 | 1134 | 1372 | 2022 | 2102 | 1679 | 865 |
| False positives | 630 | 62 | 711 | 136 | 417 | 265 | 145 | 285 | 225 | 196 | 541 | 329 | 280 | 782 | 383 |
| Total (seconds) | 3175 | 3288 | 3207 | 3270 | 3374 | 2968 | 2941 | 2733 | 3261 | 2785 | 3181 | 3033 | 3332 | 3480 | 3716 |
| **Sensitivity (%)** | **98.1** | **96.7** | **90.6** | **96.7** | **81.6** | **71.5** | **81.6** | **70.0** | **98.3** | **91.2** | **92.4** | **73.8** | **88.2** | **96.4** | **89.8** |
| **Specificity (%)** | **56.4** | **97.9** | **72.9** | **95.6** | **81.9** | **88.8** | **93.4** | **87.2** | **87.7** | **85.3** | **71.7** | **86.0** | **88.2** | **68.2** | **69.3** |
| **Positive predictive value (%)** | **72.9** | **82.4** | **42.7** | **59.8** | **67.7** | **61.5** | **80.4** | **55.8** | **86.3** | **87.1** | **68.4** | **60.5** | **75.0** | **55.7** | **85.3** |

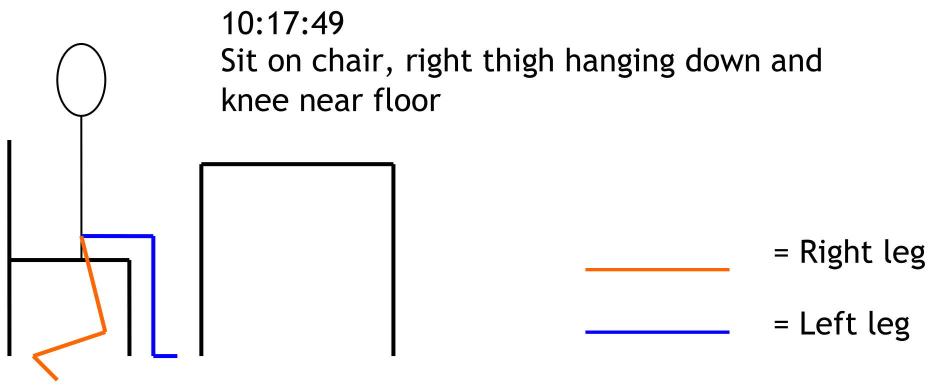
**Table 21 *activ*PAL™ stand output against direct observation, child N0016-N0032**

| | N0001 | N0002 | N0003 | N0004 | N0005 | N0006 | N0007 | N0008 | N0009 | N0010 | N0011 | N0012 | N0013 | N0014 | N0015 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| True positives | 173 | 230 | 188 | 182 | 717 | 964 | 124 | 173 | 533 | 895 | 82 | 206 | 318 | 695 | 431 |
| False negatives | 30 | 58 | 19 | 5 | 44 | 87 | 35 | 27 | 79 | 123 | 40 | 59 | 47 | 58 | 172 |
| True negatives | 2997 | 2908 | 2913 | 2762 | 1453 | 1806 | 3323 | 3150 | 3094 | 1577 | 3592 | 3020 | 3143 | 1846 | 2519 |
| False positives | 62 | 123 | 28 | 77 | 138 | 128 | 124 | 81 | 143 | 168 | 37 | 97 | 70 | 64 | 50 |
| Total (seconds) | 3262 | 3319 | 3148 | 3026 | 2352 | 2985 | 3606 | 3431 | 3849 | 2763 | 3751 | 3382 | 3578 | 2663 | 3172 |
| **Sensitivity (%)** | **85.2** | **79.9** | **90.8** | **97.3** | **94.2** | **91.7** | **78.0** | **86.5** | **87.1** | **87.9** | **67.2** | **77.7** | **87.1** | **92.3** | **71.5** |
| **Specificity (%)** | **98.0** | **95.9** | **99.0** | **97.3** | **91.3** | **93.4** | **96.4** | **97.5** | **95.6** | **90.4** | **99.0** | **96.9** | **97.8** | **96.6** | **98.1** |
| **Positive predictive value (%)** | **73.6** | **65.2** | **87.0** | **70.3** | **83.9** | **88.3** | **50.0** | **68.1** | **78.8** | **84.2** | **68.9** | **68.0** | **82.0** | **91.6** | **89.6** |
| | | | | | | | | | | | | | | | |
| **Excluding all direct observation ‘Other’ seconds (i.e. excluding other, kneel up, crouch, crawl)** | | | | | | | | | | | | | | | |
| True positives | 173 | 230 | 188 | 182 | 717 | 964 | 124 | 173 | 533 | 895 | 82 | 206 | 318 | 695 | 431 |
| False negatives | 30 | 58 | 19 | 5 | 44 | 87 | 35 | 27 | 79 | 123 | 40 | 59 | 47 | 58 | 172 |
| True negatives | 2959 | 2884 | 2909 | 2750 | 1301 | 1688 | 3317 | 3137 | 3031 | 1415 | 3580 | 2814 | 2990 | 1808 | 2403 |
| False positives | 56 | 121 | 28 | 69 | 85 | 105 | 114 | 76 | 132 | 138 | 37 | 71 | 63 | 62 | 49 |
| Total (seconds) | 3218 | 3293 | 3144 | 3006 | 2147 | 2844 | 3590 | 3413 | 3775 | 2571 | 3739 | 3150 | 3418 | 2623 | 3055 |
| **Sensitivity (%)** | **85.2** | **79.9** | **90.8** | **97.3** | **94.2** | **91.7** | **78.0** | **86.5** | **87.1** | **87.9** | **67.2** | **77.7** | **87.1** | **92.3** | **71.5** |
| **Specificity (%)** | **98.1** | **96.0** | **99.0** | **97.6** | **93.9** | **94.1** | **96.7** | **97.6** | **95.8** | **91.1** | **99.0** | **97.5** | **97.9** | **96.7** | **98.0** |
| **Positive predictive value (%)** | **75.5** | **65.5** | **87.0** | **72.5** | **89.4** | **90.2** | **52.1** | **69.5** | **80.2** | **86.6** | **68.9** | **74.4** | **83.5** | **91.8** | **89.8** |

**Table 22 *activ*PAL$^{TM}$ walk output against direct observation, child N0001-N0015**

| | N0016 | N0017 | N0018 | N0019 | N0020 | N0021 | N0023 | N0024 | N0025 | N0027 | N0028 | N0029 | N0030 | N0031 | N0032 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| True positives | 374 | 113 | 136 | 78 | 387 | 1209 | 282 | 799 | 137 | 296 | 218 | 1375 | 346 | 68 | 600 |
| False negatives | 109 | 42 | 58 | 41 | 170 | 261 | 127 | 149 | 80 | 127 | 151 | 307 | 161 | 77 | 282 |
| True negatives | 2666 | 3184 | 3069 | 3308 | 2736 | 1333 | 2702 | 1760 | 3080 | 2258 | 2872 | 1193 | 2750 | 3334 | 2650 |
| False positives | 45 | 27 | 71 | 3 | 234 | 188 | 158 | 217 | 56 | 132 | 167 | 235 | 127 | 74 | 274 |
| Total (seconds) | 3194 | 3366 | 3334 | 3430 | 3527 | 2991 | 3269 | 2925 | 3353 | 2813 | 3408 | 3110 | 3384 | 3553 | 3806 |
| **Sensitivity (%)** | **77.4** | **72.9** | **70.1** | **65.5** | **69.5** | **82.2** | **68.9** | **84.3** | **63.1** | **70.0** | **59.1** | **81.7** | **68.2** | **46.9** | **68.0** |
| **Specificity (%)** | **98.3** | **99.2** | **97.7** | **99.9** | **92.1** | **87.6** | **94.5** | **89.0** | **98.2** | **94.5** | **94.5** | **83.5** | **95.6** | **97.8** | **90.6** |
| **Positive predictive value (%)** | **89.3** | **80.7** | **65.7** | **96.3** | **62.3** | **86.5** | **64.1** | **78.6** | **71.0** | **69.2** | **56.6** | **85.4** | **73.2** | **47.9** | **68.6** |
| | | | | | | | | | | | | | | | |
| **Excluding all direct observation 'Other' seconds (i.e. excluding other, kneel up, crouch, crawl)** | | | | | | | | | | | | | | | |
| True positives | 374 | 113 | 136 | 78 | 387 | 1209 | 282 | 799 | 137 | 296 | 218 | 1375 | 346 | 68 | 600 |
| False negatives | 109 | 42 | 58 | 41 | 170 | 261 | 127 | 149 | 80 | 127 | 151 | 307 | 161 | 77 | 282 |
| True negatives | 2650 | 3122 | 2944 | 3148 | 2599 | 1314 | 2406 | 1624 | 3009 | 2246 | 2689 | 1146 | 2710 | 3275 | 2575 |
| False positives | 42 | 11 | 69 | 3 | 218 | 184 | 126 | 161 | 35 | 116 | 123 | 205 | 115 | 60 | 259 |
| Total (seconds) | 3175 | 3288 | 3207 | 3270 | 3374 | 2968 | 2941 | 2734 | 3261 | 2785 | 3181 | 3033 | 3332 | 3480 | 3716 |
| **Sensitivity (%)** | **77.4** | **72.9** | **70.1** | **65.5** | **69.5** | **82.2** | **68.9** | **84.3** | **63.1** | **70.0** | **59.1** | **81.7** | **68.2** | **46.9** | **68.0** |
| **Specificity (%)** | **98.4** | **99.6** | **97.7** | **99.9** | **92.3** | **87.7** | **95.0** | **91.0** | **98.9** | **95.1** | **95.6** | **84.8** | **95.9** | **98.2** | **90.9** |
| **Positive predictive value (%)** | **89.9** | **91.1** | **66.3** | **96.3** | **64.0** | **86.8** | **69.1** | **83.2** | **79.7** | **71.8** | **63.9** | **87.0** | **75.1** | **53.1** | **69.8** |

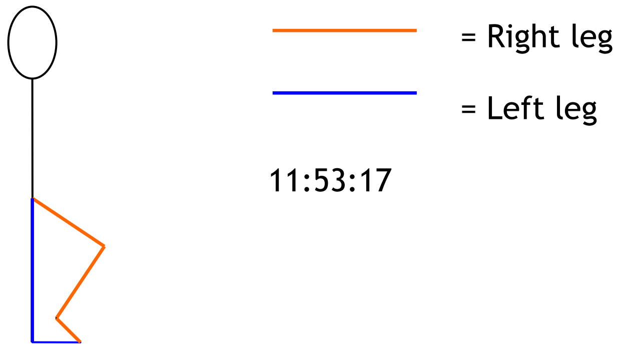
**Table 23 *activ*PAL$^{TM}$ walk output against direct observation, child N0016-N0032**




| Direct observation and monitor output (Child N0016) | | | |
|---|---|---|---|
| Time | Video | *activ*PAL™ | DynaPort |
| 10:17:47 | walk | walk | Standing |
| 10:17:48 | walk | walk | Shuffling |
| 10:17:49 | sit | walk | Shuffling |
| 10:17:50 | sit | stand | Shuffling |
| 10:17:51 | sit | stand | Standing |

**Figure 15. Example comparison between direct observation data and monitor output: sitting on chair with thigh hanging down**

Schematic diagram of child N0016 sitting on a chair with their right thigh hanging over the side of the chair and knee close to the floor at time 10:17:49. Corresponding direct observation, *activ*PAL™ and DynaPort MicroMod output are shown.




Direct observation and monitor output (Child N0004)

| Time | Video | *activ*PAL™ | DynaPort |
|---|---|---|---|
| 11:53:16 | Stand, both legs straight | stand | Standing |
| 11:53:17 | Stand, right leg as shown | stand | Standing |
| 11:53:18 | | sit/lie | Standing |
| 11:53:19 | | sit/lie | Standing |
| 11:53:20 | | stand | Standing |
| 11:53:21 | Stand, both legs straight | stand | Standing |

**Figure 16. Example comparison between direct observation data and monitor output: standing with leg bent at knee**

Schematic diagram of child standing with right foot resting on left foot, with right leg bent at knee as shown at time 11:53:17. Corresponding direct observation, *activ*PAL™ and DynaPort MicroMod output are shown.

**N0005**

| crawl | | | crouch | | | jump | | |
|---|---|---|---|---|---|---|---|---|
| sit/lie | stand | walk | sit/lie | stand | walk | sit/lie | stand | walk |
| 0 | 7 | 5 | 27 | 2 | 0 | 0 | 0 | 9 |

| kneel up | | | lie | | | other | | |
|---|---|---|---|---|---|---|---|---|
| sit/lie | stand | walk | sit/lie | stand | walk | sit/lie | stand | walk |
| 0 | 64 | 25 | 329 | 1 | 0 | 42 | 10 | 23 |

| run | | | sit | | | stand | | |
|---|---|---|---|---|---|---|---|---|
| sit/lie | stand | walk | sit/lie | stand | walk | sit/lie | stand | walk |
| 0 | 4 | 353 | 416 | 15 | 5 | 10 | 530 | 80 |

| walk | | | All |
|---|---|---|---|
| sit/lie | stand | walk | All |
| 2 | 38 | 355 | 2352 |

**N0010**

| crouch | | | jump | | | kneel up | | |
|---|---|---|---|---|---|---|---|---|
| sit/lie | stand | walk | sit/lie | stand | walk | sit/lie | stand | walk |
| 84 | 5 | 7 | 0 | 3 | 3 | 30 | 27 | 0 |

| other | | | run | | | sit | | |
|---|---|---|---|---|---|---|---|---|
| sit/lie | stand | walk | sit/lie | stand | walk | sit/lie | stand | walk |
| 13 | 3 | 23 | 3 | 20 | 527 | 804 | 8 | 2 |

| stand | | | walk | | | All |
|---|---|---|---|---|---|---|
| sit/lie | stand | walk | sit/lie | stand | walk | All |
| 22 | 581 | 136 | 3 | 94 | 365 | 2763 |

**N0012**

| crawl | | | crouch | | |
|---|---|---|---|---|---|
| sit/lie | stand | walk | sit/lie | stand | walk |
| 2 | 12 | 2 | 8 | 6 | 1 |

| jump | | | kneel up | | | lie | | |
|---|---|---|---|---|---|---|---|---|
| sit/lie | stand | walk | sit/lie | stand | walk | sit/lie | stand | walk |
| 0 | 1 | 0 | 0 | 136 | 6 | 11 | 0 | 0 |

| other | | | run | | | sit | | |
|---|---|---|---|---|---|---|---|---|
| sit/lie | stand | walk | sit/lie | stand | walk | sit/lie | stand | walk |
| 27 | 15 | 17 | 0 | 2 | 20 | 1207 | 447 | 19 |

| skip | | | stand | | | walk | | | All |
|---|---|---|---|---|---|---|---|---|---|
| sit/lie | stand | walk | sit/lie | stand | walk | sit/lie | stand | walk | All |
| 0 | 1 | 7 | 1 | 1148 | 52 | 1 | 54 | 179 | 3382 |

**Table 24 Minitab summary data for direct observation and *activ*PAL™: Child N0005, N0010, N0012**

Number of seconds in each *activ*PAL™ output category according to direct each direct observation category for N0005, N0010 and N0012. These children had >5% direct observation seconds in 'other' categories.

**N0023**

| | crawl | | | crouch | | | jump | | |
|---|---|---|---|---|---|---|---|---|---|
| | sit/lie | stand | walk | sit/lie | stand | walk | sit/lie | stand | walk |
| | 5 | 12 | 17 | 14 | 12 | 5 | 0 | 4 | 23 |
| | **kneel up** | | | **lie** | | | **other** | | |
| | sit/lie | stand | walk | sit/lie | stand | walk | sit/lie | stand | walk |
| | 1 | 6 | 0 | 115 | 17 | 7 | 120 | 126 | 10 |
| | **run** | | | **sit** | | | **stand** | | |
| | sit/lie | stand | walk | sit/lie | stand | walk | sit/lie | stand | walk |
| | 0 | 3 | 78 | 1645 | 14 | 4 | 19 | 596 | 115 |
| | **walk** | | | **All** | | | | | |
| | sit/lie | stand | walk | All | | | | | |
| | 13 | 107 | 181 | 3269 | | | | | |

**N0024**

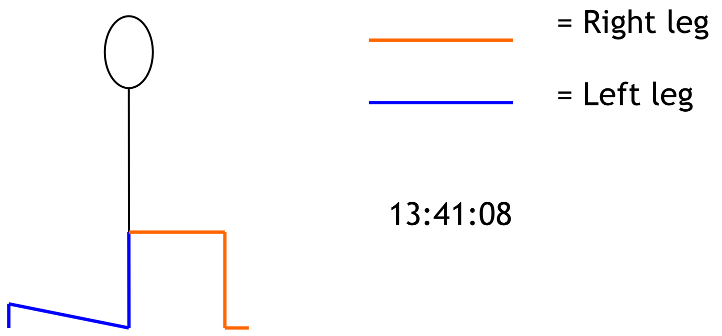
| | crouch | | | jump | | | kneel up | | |
|---|---|---|---|---|---|---|---|---|---|
| | sit/lie | stand | walk | sit/lie | stand | walk | sit/lie | stand | walk |
| | 0 | 0 | 1 | 0 | 6 | 10 | 5 | 28 | 9 |
| | **lie** | | | **other** | | | **run** | | |
| | sit/lie | stand | walk | sit/lie | stand | walk | sit/lie | stand | walk |
| | 6 | 4 | 0 | 22 | 81 | 46 | 0 | 20 | 337 |
| | **sit** | | | **skip** | | | **stand** | | |
| | sit/lie | stand | walk | sit/lie | stand | walk | sit/lie | stand | walk |
| | 1108 | 136 | 17 | 0 | 0 | 14 | 10 | 360 | 144 |
| | **walk** | | | **All** | | | | | |
| | sit/lie | stand | walk | All | | | | | |
| | 4 | 119 | 438 | 2925 | | | | | |

**N0028**

| | crawl | | | kneel up | | | lie | | |
|---|---|---|---|---|---|---|---|---|---|
| | sit/lie | stand | walk | sit/lie | stand | walk | sit/lie | stand | walk |
| | 2 | 10 | 32 | 142 | 7 | 6 | 4 | 0 | 0 |
| | **other** | | | **run** | | | **sit** | | |
| | sit/lie | stand | walk | sit/lie | stand | walk | sit/lie | stand | walk |
| | 5 | 17 | 6 | 0 | 40 | 12 | 1123 | 390 | 27 |
| | **stand** | | | **walk** | | | **All** | | |
| | sit/lie | stand | walk | sit/lie | stand | walk | All | | |
| | 1 | 1171 | 96 | 0 | 111 | 206 | 3408 | | |

**Table 25 Minitab summary data for direct observation and *activ*PAL™: Child N0023, N0024, N0028**

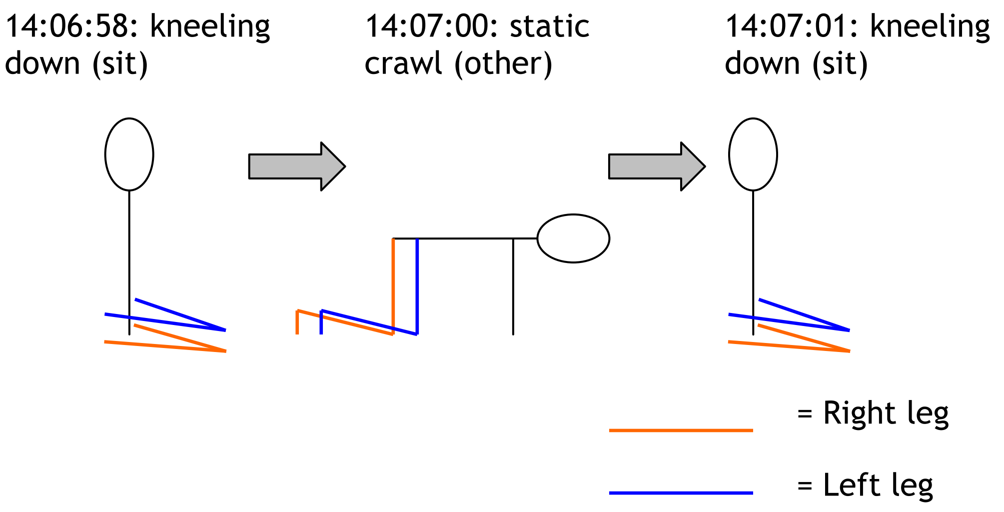
Number of seconds in each *activ*PAL™ output category according to direct each direct observation category for N0023, N0024 and N0028. These children also had >5% direct observation seconds in ‘other’ categories.




| Direct observation and monitor output (Child N0005) | | | |
|---|---|---|---|
| Time | Video | *activ*PAL™ | DynaPort |
| 13:41:08 | other | Sit/lie | Standing |

**Figure 17 Example comparison between direct observation data and monitor output: kneeling up on one knee**

Schematic diagram of child N0005 kneeling up on one knee at 13:41:08 with right thigh (site of *activ*PAL™ placement) horizontal and left thigh vertical. Corresponding direct observation, *activ*PAL™ and DynaPort MicroMod output are shown.

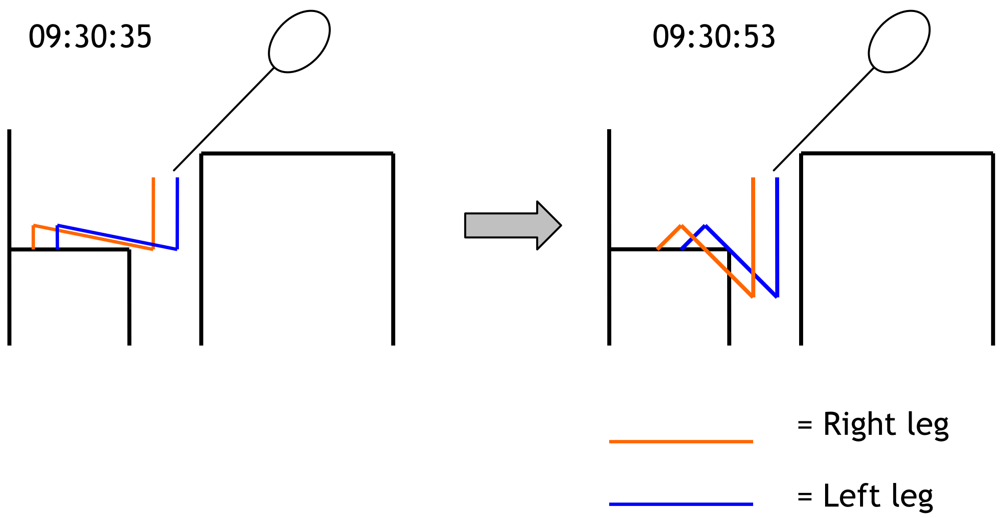



Direct observation and monitor output (Child N0005)

| Time | Video | *activ*PAL$^{TM}$ | DynaPort |
|---|---|---|---|
| 14:06:58 | sit | sit/lie | Standing |
| 14:06:59 | sit | stand | Standing |
| 14:07:00 | other | stand | Standing |
| 14:07:01 | sit | sit/lie | Standing |
| 14:07:02 | sit | Sit/lie | Sitting |

**Figure 18. Example comparison between direct observation data and monitor output: kneeling down to static crawl**

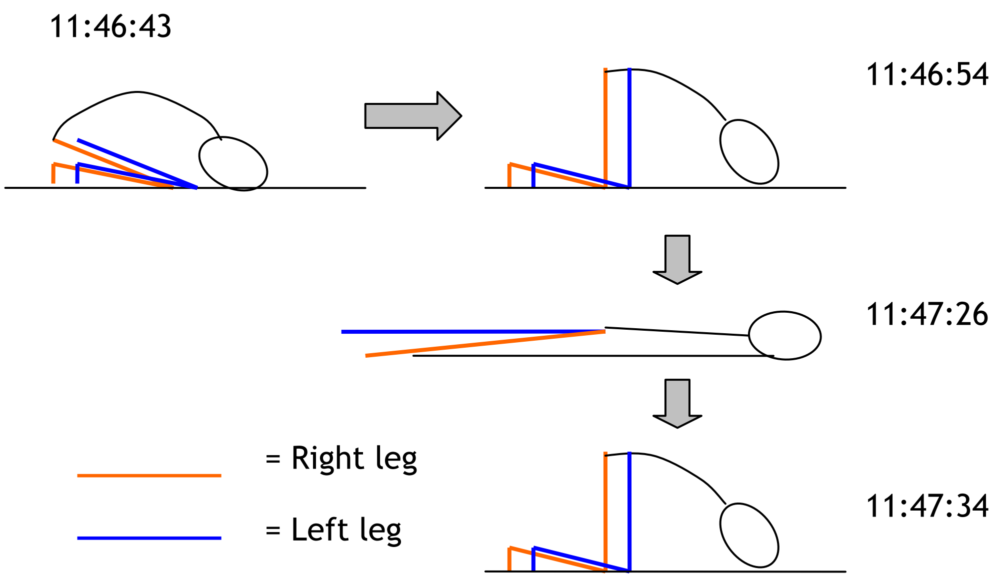
Schematic diagram of child N0005 kneeling down at 14:06:58, transition to 'static crawl' position at 14:07:00 and transition back to kneel down at 14:07:01. Corresponding direct observation, *activ*PAL$^{TM}$ and DynaPort MicroMod output are shown.




| Direct observation and monitor output (Child N0012) | | | |
|---|---|---|---|
| Time | Video | *activ*PAL™ | DynaPort |
| 09:30:35 | other | Stand | Standing |
| 09:30:36 | other | stand | Standing |
| | | | |
| 09:30:53 | other | Stand | Standing |
| 09:30:54 | other | stand | standing |

**Figure 19. Example comparison between direct observation data and monitor output: hanging over edge of chair**

Schematic diagram of child N0012 kneeling up on a chair at 09:30:35, then sliding forward so that both knees were hanging down over the edge of the chair with trunk leaning forward on the table at 09:30:53. Corresponding direct observation, *activ*PAL™ and DynaPort MicroMod output are shown.

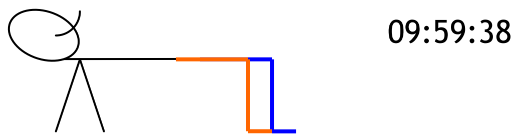



Direct observation and monitor output (Child N0017)

| Time | Video | *activ*PAL™ | DynaPort |
|---|---|---|---|
| 11:46:43 | other | Stand | Standing |
| 11:46:44 | Other | Stand | Standing |
| 11:46:45 | Other | Sit/lie | Standing |
| | | | |
| 11:46:52 | other | Sit/lie | standing |
| 11:46:53 | Other | Stand | Standing |
| 11:46:54 | Other | Stand | Standing |
| | | | |
| 11:47:25 | other | stand | Standing |
| 11:47:26 | Lie | Sit/lie | Standing |
| 11:47:27 | lie | Sit/lie | Standing |
| | | | |
| 11:47:33 | lie | Sit/lie | Standing |
| 11:47:34 | other | stand | standing |

**Figure 20 Example comparison between direct observation data and monitor output: 'fetal' position and transition**

Schematic diagram of child N0017 curled up in the 'fetal' position at 11:46:43, then leaning forward with head resting in air and thighs perpendicular to the floor at 11:46:54. At 11:47:26 she then lay face down on the floor before returning to the position of 11:46:54 at 11:47:34. Corresponding direct observation, *activ*PAL™ and DynaPort MicroMod output are shown.




Direct observation and monitor output (Child N0023)

| Time | Video | *activ*PAL™ | DynaPort |
|---|---|---|---|
| 09:59:37 | sit | Sit/lie | Sitting |
| 09:59:38 | other | Sit/lie | Sitting |
| 09:59:39 | sit | Sit/lie | Sitting |
| 09:59:40 | Sit | Sit/lie | Lying |
| 09:59:41 | other | Sit/lie | Lying |
| 09:59:42 | sit | Sit/lie | Lying |

**Figure 21 Example comparison between direct observation data and monitor output: 'crab' position**

Schematic diagram of child N0023 in the 'crab' position, facing the ceiling. This posture was adopted for two brief (1 second duration) periods at 09:59:38 and 09:59:41. Corresponding direct observation, *activ*PAL™ and DynaPort MicroMod output are shown.

**N0021**

| crouch | | | jump | | | lie | | |
|---|---|---|---|---|---|---|---|---|
| sit/lie | stand | walk | sit/lie | stand | walk | sit/lie | stand | walk |
| 6 | 3 | 4 | 0 | 0 | 3 | 2 | 4 | 0 |

| other | | | peddle | | | run | | |
|---|---|---|---|---|---|---|---|---|
| sit/lie | stand | walk | sit/lie | stand | walk | sit/lie | stand | walk |
| 9 | 1 | 0 | 319 | 2 | 1 | 2 | 9 | 251 |

| sit | | | stand | | | walk | | | All |
|---|---|---|---|---|---|---|---|---|---|
| sit/lie | stand | walk | sit/lie | stand | walk | sit/lie | stand | walk | All |
| 519 | 38 | 21 | 7 | 423 | 162 | 38 | 212 | 955 | 2991 |

**N0029**

| crouch | | | jump | | | lie | | |
|---|---|---|---|---|---|---|---|---|
| sit/lie | stand | walk | sit/lie | stand | walk | sit/lie | stand | walk |
| 17 | 10 | 9 | 0 | 7 | 49 | 0 | 0 | 7 |

| other | | | peddle | | | run | | |
|---|---|---|---|---|---|---|---|---|
| sit/lie | stand | walk | sit/lie | stand | walk | sit/lie | stand | walk |
| 14 | 6 | 21 | 248 | 22 | 6 | 0 | 14 | 251 |

| sit | | | skip | | | stand | | |
|---|---|---|---|---|---|---|---|---|
| sit/lie | stand | walk | sit/lie | stand | walk | sit/lie | stand | walk |
| 317 | 42 | 27 | 0 | 1 | 12 | 14 | 503 | 165 |

| walk | | | All |
|---|---|---|---|
| sit/lie | stand | walk | All |
| 42 | 243 | 1063 | 3110 |

**Table 26 Minitab summary data for direct observation and *activ*PAL$^{TM}$: Child N0021, N0029 (Including direct observation 'Peddle')**

Number of seconds in each *activ*PAL$^{TM}$ output category according to direct each direct observation category for N0021 and N0029. These children sat peddling on a tricycle during direct observation.

## 3.8 Agreement between DynaPort and video observation

The results for validation of the DynaPort MicroMod against direct observation are presented in the same format as described above for the *activ*PAL™. The DynaPort MicroMod output for the total monitoring period for all children with a complete data set is shown in tables 27 and 28. This output encompasses all on screen seconds (on which direct observation comparisons were made) and off screen seconds where activity could not be visualised. Tables 29 and 30 are the DynaPort MicroMod output for all on screen seconds only, for each child. The median on screen time spent in each DynaPort MicroMod output category was 27.0 % (IQR 14.7-46.9) for sit, 41.2% (IQR 29.2-52.0) for stand, 9.7% (IQR 5.8-19.9) for walk, and 9.3% (IQR 6.5-12.6) for shuffle.

Cumulative DynaPort MicroMod data for the 97,933 on screen seconds on which comparisons with direct observation data were based categorised 30,904 seconds (31.6%) as sit, 1829 seconds (1.9%) as lie, 40,995 seconds (41.9%) as stand, 14,399 seconds (14.7%) as walk and 9806 seconds (10.0%) as shuffle. Comparison of the direct observation data with DynaPort MicroMod output is shown in figures 22 and 23 (Sit and Lie output have been combined). The proportion of seconds identified as walking by direct observation correlated significantly with the proportion of seconds identified as walking by the DynaPort MicroMod ($r = 0.99$ $p < 0.001$) represented graphically in figure 24. DynaPort MicroMod output for stand correlated significantly but less well with direct observation stand ($r = 0.56$ $p = 0.001$), figure 25. However, similar to the *activ*PAL™ the DynaPort MicroMod tended to overestimate time spent standing, and the magnitude of this bias is demonstrated in the Bland Altman plot direct observation 'stand' seconds vs. DynaPort MicroMod output 'stand' seconds (figure 28). Conversely DynaPort MicroMod output for sit and lie correlated significantly with direct observation sit/lie ($r = 0.72$, $p < 0.001$) but again tended to underestimate total number of seconds spent sitting/lying (figures 26 and 27). The Bland Altman plots are shown in figure 28. The average bias in overestimating the time spent standing was comparable for both DynaPort and *activ*PAL™ monitors (average bias +7.1% for *activ*PAL™, +6.8% for DynaPort compared to direct observation proportion of time spent in 'stand'). Both monitors underestimated time spent sitting (average bias –4.4% for *activ*PAL™, -12.5% for DynaPort compared to direct observation) in comparison to direct observation.

Sensitivity, specificity and positive predictive values (PPVs) for the DynaPort MicroMod outputs of sit, stand and walk are shown for each child in tables 31 to 36. Calculations were made both including and excluding 'other' seconds as described in Methods. DynaPort shuffle output was not considered to be a true positive for stand or walk for direct comparison with direct observation categories. However, the effect of including shuffle with walk output against direct observation walk is shown in table x.

Cumulating the data from all 30 children (and including all 'other' seconds), 26237 seconds were correctly identified as sit (true positives), 17408 seconds were not identified as sit when they should have been (false negatives), 49621 seconds correctly identified as not sit (true negatives) and 4667 seconds were identified as sit when they were not (false positives). Thus the overall sensitivity for DynaPort MicroMod sit was 60.1%, specificity 91.4% and PPV 84.9%. For individual children, the median sensitivity for DynaPort MicroMod sit was 57.0% (interquartile range 40.8-75.3%, minimum 0%), specificity 96.1% (IQR 88.6-98.4%, minimum 45.3%), and positive predictive value 91.4% (IQR 74.9-95.7%, minimum 0%). Excluding 'other' seconds as for *activ*PAL™ results, overall (cumulative) specificity was 92.1% and PPV 86.7%. For individual children, the median specificity was 96.5% (IQR 93.4-99.1%, minimum 44.8%) and median positive predictive value 93.5% (IQR 78.2-98.4, minimum 0%).

As described above, the overall proportion of time spent lying was 2%, and only 15 children spent any seconds in this category according to direct observation. Furthermore, for ten of these children the total observed time lying was ≤20 seconds for their entire data collection period. However, the remaining five children all spent >100 seconds in direct observation 'lie'. Analysing the results of these five children only, the overall sensitivity for DynaPort MicroMod detection of 'lie' was 79.%, specificity 96.8% and positive predictive value 73.9%.

The cumulative overall sensitivity for DynaPort MicroMod stand was 66.3%, specificity 71.2% and PPV 55.2%. For individual children, the median sensitivity for DynaPort MicroMod stand was 68.5% (interquartile range 58.1-75.7%, minimum 27.3%), specificity 74.9% (IQR 65.7-82.8%, minimum 39.4%), and positive predictive value 50.5% (IQR 35.5-77.6%, minimum 10.3%). As before, excluding ‘other’ seconds, overall specificity was 72.6% and PPV 57.6%. For individual children, the median specificity was 76.1% (IQR 70.6-86.0%, minimum 39.7%) and PPV 51.5% (IQR 38.1-79.0, minimum 10.8%).

The cumulative overall sensitivity for DynaPort MicroMod walk was 72.2%, specificity 96.1 % and PPV 77.6%. For individual children, the median sensitivity for DynaPort MicroMod walk was 71.2% (interquartile range 64.4-80.0%, minimum 43.4%), specificity 97.3% (IQR 94.8-98.6%, minimum 64.7%), and positive predictive value 79.1% (IQR 73.1-84.8%, minimum 50.5%). As previously described, data were also presented by excluding ‘other’ seconds: with these excluded overall specificity for walk was 96.2%, PPV 78.7%. For individual children, the median specificity was 97.3% (IQR 94.9-98.9%, minimum 64.8%) and median PPV 81.6% (IQR 73.6-86.0, minimum 50.9%). When DynaPort MicroMod output shuffle was considered to represent walk, the sensitivity increased, with a reduction in specificity and positive predictive value (table 37).

The DynaPort MicroMod output for all children (n=6) with >5% of the direct observation period in postures categorised as ‘other’ (crawl, crouch, kneel up and other) is shown in tables 38 to 41. Kneel up was most often classified by DynaPort MicroMod as stand (although as for *activ*PAL$^{TM}$, for child N0028 the predominant output was for sit). Unlike for the *activ*PAL$^{TM}$, there was no clear single output for crouch or crawl. Again, the ‘other’ (requiring diagram) seconds were categorised as a combination of all three outputs, reflecting the heterogeneity of posture and activity comprising this group. An example of the DynaPort MicroMod output and direct observation data is shown in the Appendix 5.3.

The DynaPort MicroMod output for peddle (and other categories) for the two children who peddled on a tricycle during the observation period (N0021 and N0029) is shown in table 42. For both children, sitting peddling tended to be detected as walking or shuffling by the DynaPort.

### *3.8.1 DynaPort MicroMod validation: tables and figures*

| | N0001 | N0002 | N0003 | N0004 | N0005 | N0006 | N0007 | N0008 | N0009 | N0010 | N0011 | N0012 | N0013 | N0014 | N0015 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **DynaPort MicroMod output category (seconds)** | | | | | | | | | | | | | | | |
| Sit | 947 | 885 | 1981 | 1936 | 635 | 566 | 484 | 227 | 920 | 510 | 2675 | 488 | 1957 | 1127 | 808 |
| Lie | 0 | 0 | 0 | 0 | 409 | 299 | 0 | 0 | 0 | 0 | 0 | 90 | 14 | | 6 |
| Shuffle | 305 | 311 | 212 | 147 | 394 | 316 | 682 | 670 | 503 | 396 | 120 | 553 | 229 | 390 | 467 |
| Stand | 1985 | 1898 | 924 | 1024 | 961 | 1226 | 2250 | 2323 | 2735 | 1314 | 885 | 2183 | 1082 | 1182 | 1652 |
| Walk | 208 | 254 | 322 | 331 | 902 | 1111 | 210 | 413 | 673 | 1452 | 240 | 321 | 323 | 1348 | 636 |
| Total | 3445 | 3348 | 3439 | 3438 | 3301 | 3518 | 3626 | 3633 | 4831 | 3672 | 3920 | 3635 | 3605 | 4047 | 3569 |
| **DynaPort MicroMod % total monitored time** | | | | | | | | | | | | | | | |
| Sit | 27.5 | 26.4 | 57.6 | 56.3 | 19.2 | 16.1 | 13.3 | 6.2 | 19.0 | 13.9 | 68.2 | 13.4 | 54.3 | 27.8 | 22.6 |
| Lie | 0.0 | 0.0 | 0.0 | 0.0 | 12.4 | 8.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.5 | 0.4 | 0.0 | 0.2 |
| Shuffle | 8.9 | 9.3 | 6.2 | 4.3 | 11.9 | 9.0 | 18.8 | 18.4 | 10.4 | 10.8 | 3.1 | 15.2 | 6.4 | 9.6 | 13.1 |
| Stand | 57.6 | 56.7 | 26.9 | 29.8 | 29.1 | 34.8 | 62.1 | 63.9 | 56.6 | 35.8 | 22.6 | 60.1 | 30.0 | 29.2 | 46.3 |
| Walk | 6.0 | 7.6 | 9.4 | 9.6 | 27.3 | 31.6 | 5.8 | 11.4 | 13.9 | 39.5 | 6.1 | 8.8 | 9.0 | 33.3 | 17.8 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

**Table 27 Number of seconds and % total time in DynaPort MicroMod output category (sit, lie, shuffle. stand or walk) Child N0001-N0015**

| | N0016 | N0017 | N0018 | N0019 | N0020 | N0021 | N0023 | N0024 | N0025 | N0027 | N0028 | N0029 | N0030 | N0031 | N0032 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **DynaPort MicroMod output category (seconds)** | | | | | | | | | | | | | | | |
| Sit | 850 | 2327 | 1365 | 1718 | 849 | 211 | 1045 | 905 | 1682 | 1265 | 1122 | 157 | 1249 | 1899 | 206 |
| Lie | 0 | 466 | 0 | 0 | 380 | 0 | 197 | 0 | 0 | 0 | 7 | 0 | 0 | 14 | 0 |
| Shuffle | 357 | 100 | 239 | 195 | 364 | 527 | 472 | 502 | 157 | 310 | 423 | 699 | 460 | 521 | 796 |
| Stand | 1756 | 642 | 1891 | 1578 | 1351 | 1063 | 1976 | 1094 | 1552 | 1760 | 1900 | 942 | 1611 | 1997 | 2133 |
| Walk | 596 | 137 | 129 | 130 | 675 | 1761 | 1363 | 1806 | 285 | 581 | 467 | 1754 | 409 | 936 | 845 |
| Total | 3559 | 3672 | 3624 | 3621 | 3619 | 3562 | 5053 | 4307 | 3676 | 3916 | 3919 | 3552 | 3729 | 5367 | 3980 |
| **DynaPort MicroMod % total monitored time** | | | | | | | | | | | | | | | |
| Sit | 23.9 | 63.4 | 37.7 | 47.4 | 23.5 | 5.9 | 20.7 | 21.0 | 45.8 | 32.3 | 28.6 | 4.4 | 33.5 | 35.4 | 5.2 |
| Lie | 0.0 | 12.7 | 0.0 | 0.0 | 10.5 | 0.0 | 3.9 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.3 | 0.0 |
| Shuffle | 10.0 | 2.7 | 6.6 | 5.4 | 10.1 | 14.8 | 9.3 | 11.7 | 4.3 | 7.9 | 10.8 | 19.7 | 12.3 | 9.7 | 20.0 |
| Stand | 49.3 | 17.5 | 52.2 | 43.6 | 37.3 | 29.8 | 39.1 | 25.4 | 42.2 | 44.9 | 48.5 | 26.5 | 43.2 | 37.2 | 53.6 |
| Walk | 16.7 | 3.7 | 3.6 | 3.6 | 18.7 | 49.4 | 27.0 | 41.9 | 7.8 | 14.8 | 11.9 | 49.4 | 11.0 | 17.4 | 21.2 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

**Table 28 Number of seconds and % total time in DynaPort MicroMod output category (sit, lie, shuffle. stand or walk) Child N0016-N0032**

| | N0001 | N0002 | N0003 | N0004 | N0005 | N0006 | N0007 | N0008 | N0009 | N0010 | N0011 | N0012 | N0013 | N0014 | N0015 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **DynaPort MicroMod output category (seconds)** | | | | | | | | | | | | | | | |
| Sit | 888 | 885 | 1968 | 1872 | 245 | 510 | 480 | 227 | 715 | 387 | 2664 | 470 | 1944 | 993 | 783 |
| Lie | 0 | | | | 373 | 291 | | | 0 | | 0 | 82 | 14 | | 5 |
| Shuffle | 295 | 306 | 182 | 127 | 321 | 266 | 681 | 645 | 317 | 258 | 109 | 514 | 228 | 230 | 409 |
| Stand | 1888 | 1878 | 801 | 858 | 679 | 992 | 2246 | 2250 | 2325 | 1019 | 833 | 2024 | 1080 | 724 | 1488 |
| Walk | 194 | 247 | 201 | 175 | 738 | 932 | 204 | 319 | 501 | 1106 | 145 | 296 | 316 | 725 | 497 |
| Sum | 3265 | 3316 | 3152 | 3032 | 2356 | 2991 | 3611 | 3441 | 3858 | 2770 | 3751 | 3386 | 3582 | 2672 | 3182 |
| **% time spent in DynaPort MicroMod category** | | | | | | | | | | | | | | | |
| Sit | 27.2 | 26.7 | 62.4 | 61.7 | 10.4 | 17.1 | 13.3 | 6.6 | 18.5 | 14.0 | 71.0 | 13.9 | 54.3 | 37.2 | 24.6 |
| Lie | 0.0 | 0.0 | 0.0 | 0.0 | 15.8 | 9.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.4 | 0.4 | 0.0 | 0.2 |
| Shuffle | 9.0 | 9.2 | 5.8 | 4.2 | 13.6 | 8.9 | 18.9 | 18.7 | 8.2 | 9.3 | 2.9 | 15.2 | 6.4 | 8.6 | 12.9 |
| Stand | 57.8 | 56.6 | 25.4 | 28.3 | 28.8 | 33.2 | 62.2 | 65.4 | 60.3 | 36.8 | 22.2 | 59.8 | 30.2 | 27.1 | 46.8 |
| Walk | 5.9 | 7.4 | 6.4 | 5.8 | 31.3 | 31.2 | 5.6 | 9.3 | 13.0 | 39.9 | 3.9 | 8.7 | 8.8 | 27.1 | 15.6 |
| Sum | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

**Table 29 Number of seconds and % total time in DynaPort output category (sit, lie, shuffle, stand or walk) for 'On Screen' seconds only. Child N0001-N0015**

| | N0016 | N0017 | N0018 | N0019 | N0020 | N0021 | N0023 | N0024 | N0025 | N0027 | N0028 | N0029 | N0030 | N0031 | N0032 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **DynaPort MicroMod output category (seconds)** | | | | | | | | | | | | | | | |
| Sit | 832 | 2275 | 1310 | 1712 | 849 | 170 | 1000 | 891 | 1678 | 755 | 1086 | 146 | 1209 | 1757 | 203 |
| Lie | 0 | 466 | | | 380 | 0 | 197 | 0 | 0 | 0 | 7 | | | 14 | 0 |
| Shuffle | 307 | 50 | 203 | 144 | 356 | 426 | 318 | 325 | 133 | 262 | 360 | 598 | 407 | 249 | 780 |
| Stand | 1666 | 462 | 1727 | 1490 | 1281 | 918 | 1396 | 704 | 1348 | 1428 | 1701 | 878 | 1426 | 1426 | 2059 |
| Walk | 396 | 116 | 98 | 85 | 658 | 1503 | 354 | 1022 | 194 | 370 | 261 | 1517 | 345 | 107 | 777 |
| Sum | 3201 | 3369 | 3338 | 3431 | 3524 | 3017 | 3265 | 2942 | 3353 | 2815 | 3415 | 3139 | 3387 | 3553 | 3819 |
| **% time spent in DynaPort MicroMod category** | | | | | | | | | | | | | | | |
| Sit | 26.0 | 67.5 | 39.2 | 49.9 | 24.1 | 5.6 | 30.6 | 30.3 | 50.0 | 26.8 | 31.8 | 4.7 | 35.7 | 49.5 | 5.3 |
| Lie | 0.0 | 13.8 | 0.0 | 0.0 | 10.8 | 0.0 | 6.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.4 | 0.0 |
| Shuffle | 9.6 | 1.5 | 6.1 | 4.2 | 10.1 | 14.1 | 9.7 | 11.0 | 4.0 | 9.3 | 10.5 | 19.1 | 12.0 | 7.0 | 20.4 |
| Stand | 52.0 | 13.7 | 51.7 | 43.4 | 36.4 | 30.4 | 42.8 | 23.9 | 40.2 | 50.7 | 49.8 | 28.0 | 42.1 | 40.1 | 53.9 |
| Walk | 12.4 | 3.4 | 2.9 | 2.5 | 18.7 | 49.8 | 10.8 | 34.7 | 5.8 | 13.1 | 7.6 | 48.3 | 10.2 | 3.0 | 20.3 |
| Sum | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

**Table 30 Number of seconds and % total time in DynaPort output category (sit, lie, shuffle, stand or walk) for 'On Screen' seconds only. Child N0016-N0032**

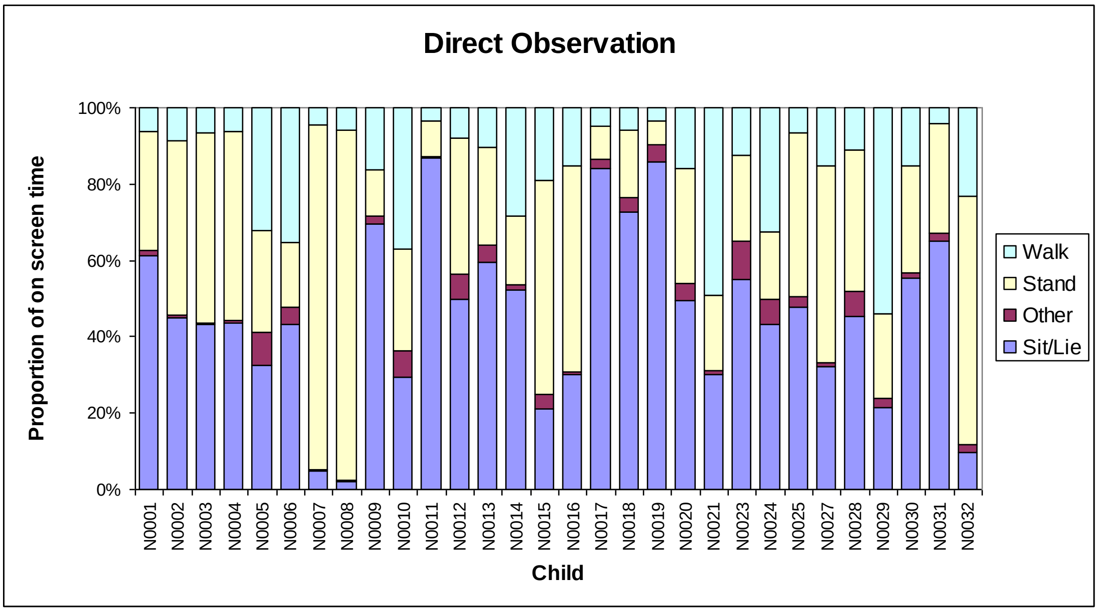



**Figure 22. Proportion of on screen time according to direct observation for each child**

Direct observation ‘Walk’ includes walk, run, jump, skip, and dance. ‘Other’ includes crouch, kneel up, crawl and ‘other’. Sit/lie includes sit, lie and peddle.

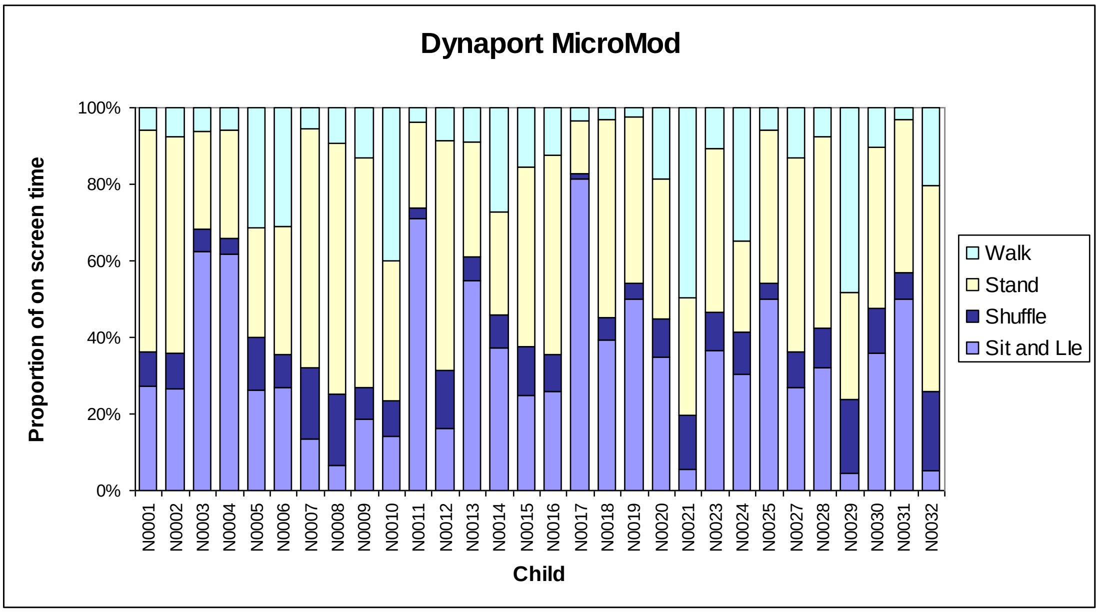



**Figure 23. Proportion of on screen time according to DynaPort MicroMod output category (walk, stand, shuffle or sit and lie)**

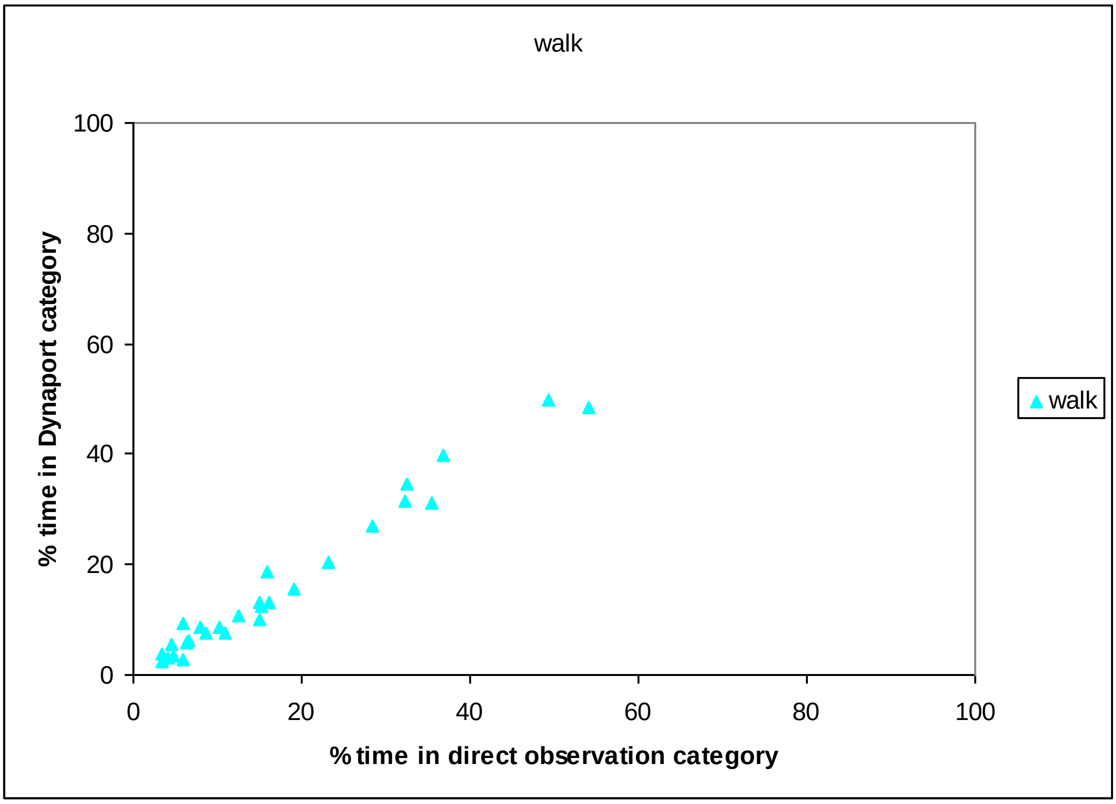



**Figure 24. Proportion of on screen time spent in DynaPort MicroMod walk against proportion of time spend in direct observation category walk**

Each child is represented by an individual data point, r=0.99, p<0.001. Direct observation walk included walk, run, dance, jump and skip.

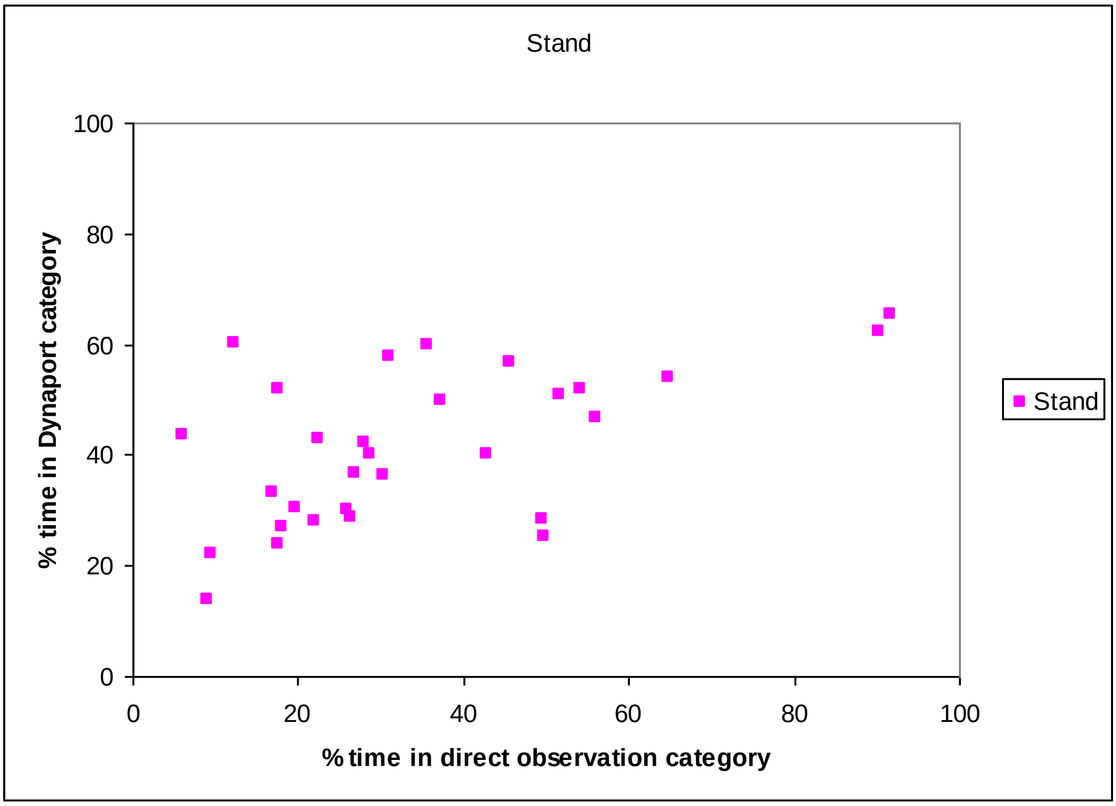



**Figure 25. Proportion of on screen time in DynaPort stand category stand against proportion of time in direct observation category stand.**

Each child is represented by an individual data point, r = 0.56, p=0.001

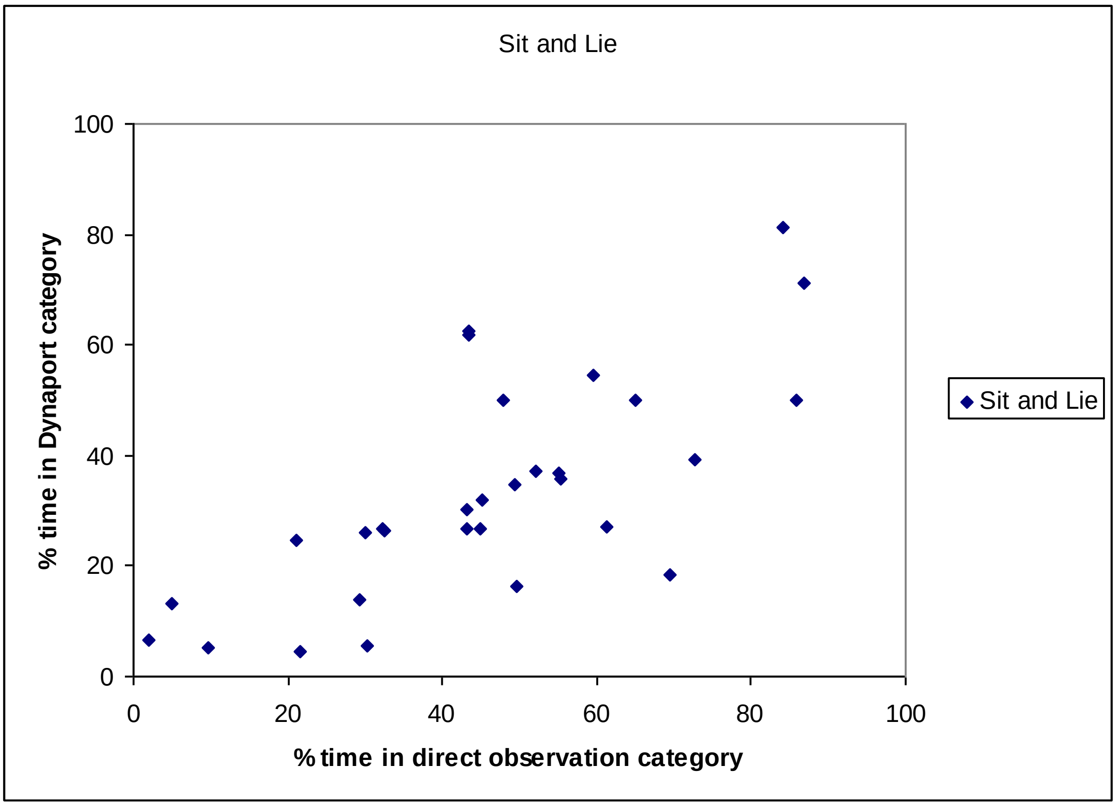



**Figure 26. Proportion of on screen time in DynaPort MicroMod category sit and lie against proportion of time in direct observation categories sit and lie**

Each child is represented by an individual data point, r = 0.72, $p<0.001$

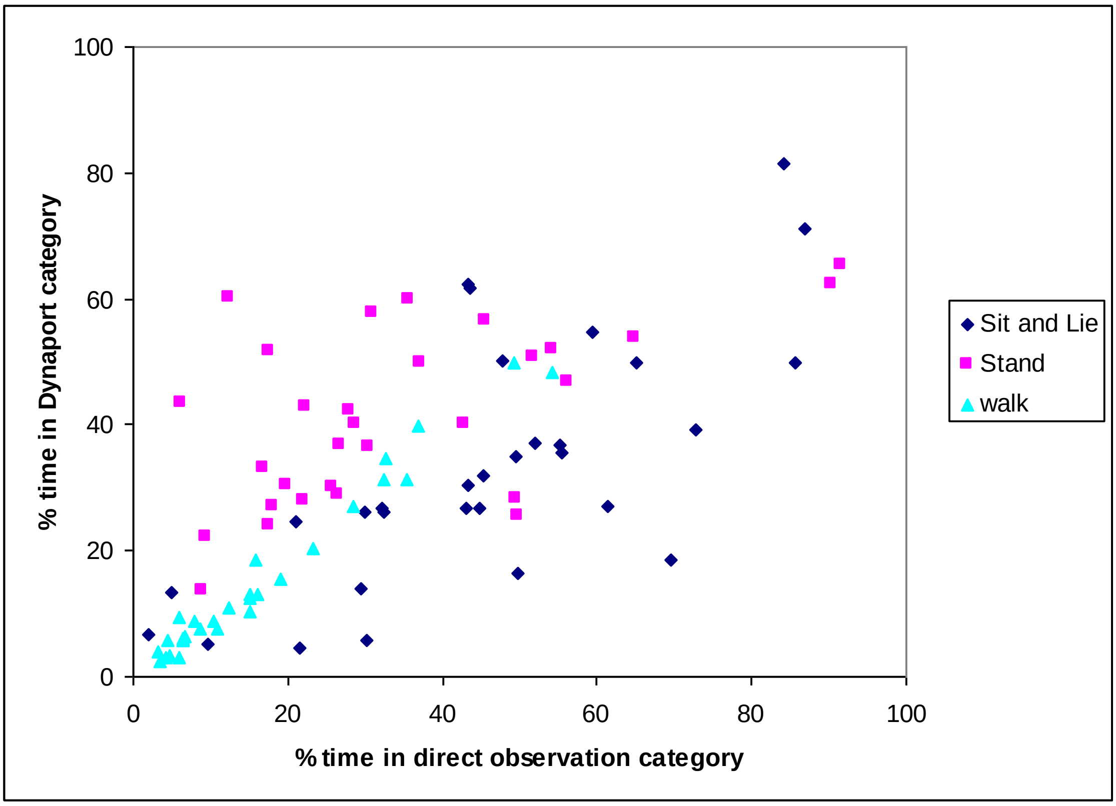



**Figure 27. Overall summary comparing proportion of time in DynaPort MicroMod category with direct observation category**

Each child is represented by a data point for sit/lie, stand and walk. Correlation coefficients as previously quoted.

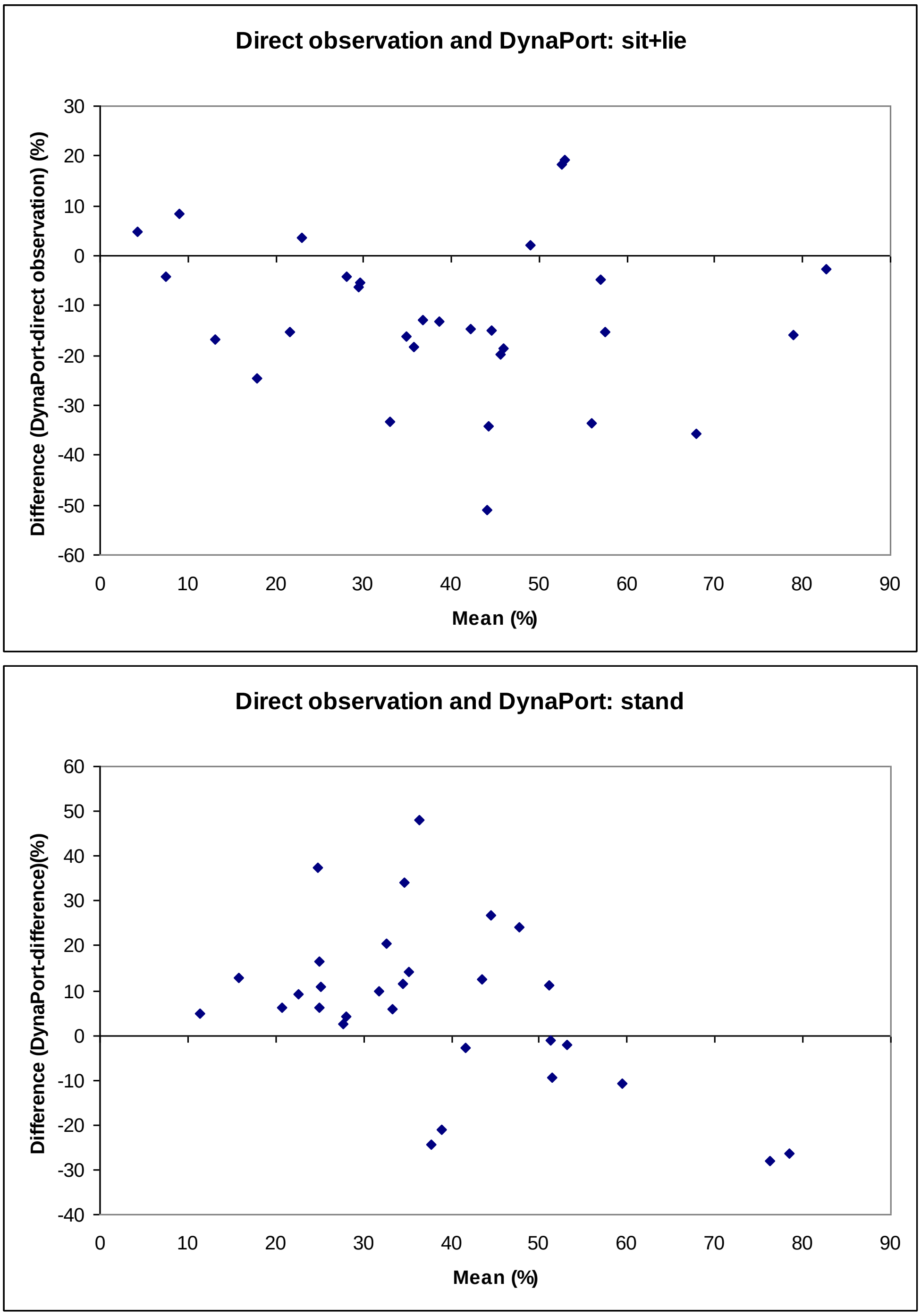



**Figure 28. Bland Altman plots for DynaPort and direct observation**

Bland Altman plots for proportion of on screen seconds in direct observation sit + lie and DynaPort MicroMod sit and lie and DynaPort MicroMod stand as shown. Each child is represented by an individual data point. The DynaPort tended to underestimate time sitting (bias -12.5%, 95% limit of agreement -43.5% to 18.5%, r= -0.16, p=0.39). Conversely the proportion of time detected by the DynaPort MicroMod as stand tended to be overestimated (bias 6.8%, 95% limit of agreement -28.6% to 42.1%, r=-0.49, p=0.006).

| | N0001 | N0002 | N0003 | N0004 | N0005 | N0006 | N0007 | N0008 | N0009 | N0010 | N0011 | N0012 | N0013 | N0014 | N0015 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| True positives | 831 | 442 | 1281 | 935 | 216 | 446 | 86 | 0 | 668 | 382 | 2660 | 379 | 1782 | 976 | 585 |
| False negatives | 1170 | 1047 | 85 | 383 | 220 | 654 | 89 | 66 | 2017 | 432 | 595 | 1293 | 347 | 416 | 85 |
| True negatives | 1207 | 1384 | 1099 | 777 | 1891 | 1827 | 3042 | 3148 | 1126 | 1951 | 492 | 1623 | 1291 | 1263 | 2314 |
| False positives | 57 | 443 | 687 | 937 | 29 | 64 | 394 | 227 | 47 | 5 | 4 | 91 | 162 | 17 | 198 |
| Total (seconds) | 3265 | 3316 | 3152 | 3032 | 2356 | 2991 | 3611 | 3441 | 3858 | 2770 | 3751 | 3386 | 3582 | 2672 | 3182 |
| **sensitivity %** | **41.5** | **29.7** | **93.8** | **70.9** | **49.5** | **40.5** | **49.1** | **0.0** | **24.9** | **46.9** | **81.7** | **22.7** | **83.7** | **70.1** | **87.3** |
| **specificity %** | **95.5** | **75.8** | **61.5** | **45.3** | **98.5** | **96.6** | **88.5** | **93.3** | **96.0** | **99.7** | **99.2** | **94.7** | **88.9** | **98.7** | **92.1** |
| **positive predictive value %** | **93.6** | **49.9** | **65.1** | **49.9** | **88.2** | **87.5** | **17.9** | **0.0** | **93.4** | **98.7** | **99.8** | **80.6** | **91.7** | **98.3** | **74.7** |
| | | | | | | | | | | | | | | | |
| **Excluding all direct observation ‘Other’ seconds (i.e. excluding other, kneel up, crouch, crawl)** | | | | | | | | | | | | | | | |
| True positives | 831 | 442 | 1281 | 935 | 216 | 446 | 86 | 0 | 668 | 382 | 2660 | 379 | 1782 | 976 | 585 |
| False negatives | 1170 | 1047 | 85 | 383 | 220 | 654 | 89 | 66 | 2017 | 432 | 595 | 1293 | 347 | 416 | 85 |
| True negatives | 1163 | 1360 | 1095 | 758 | 1696 | 1705 | 3028 | 3131 | 1069 | 1760 | 481 | 1417 | 1251 | 1236 | 2208 |
| False positives | 57 | 442 | 687 | 935 | 19 | 48 | 392 | 226 | 30 | 5 | 3 | 65 | 42 | 4 | 186 |
| Total (seconds) | 3221 | 3291 | 3148 | 3011 | 2151 | 2853 | 3595 | 3423 | 3784 | 2579 | 3739 | 3154 | 3422 | 2632 | 3064 |
| **sensitivity %** | **41.5** | **29.7** | **93.8** | **70.9** | **49.5** | **40.5** | **49.1** | **0.0** | **24.9** | **46.9** | **81.7** | **22.7** | **83.7** | **70.1** | **87.3** |
| **specificity %** | **95.3** | **75.5** | **61.4** | **44.8** | **98.9** | **97.3** | **88.5** | **93.3** | **97.3** | **99.7** | **99.4** | **95.6** | **96.8** | **99.7** | **92.2** |
| **positive predictive value %** | **93.6** | **50.0** | **65.1** | **50.0** | **91.9** | **90.3** | **18.0** | **0.0** | **95.7** | **98.7** | **99.9** | **85.4** | **97.7** | **99.6** | **75.9** |

**Table 31 DynaPort MicroMod sit output against direct observation, child N0001-N0015**

| | N0016 | N0017 | N0018 | N0019 | N0020 | N0021 | N0023 | N0024 | N0025 | N0027 | N0028 | N0029 | N0030 | N0031 | N0032 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| True positives | 815 | 2267 | 1151 | 1622 | 805 | 161 | 981 | 846 | 1420 | 688 | 820 | 55 | 1160 | 1703 | 74 |
| False negatives | 147 | 20 | 1274 | 1320 | 562 | 746 | 682 | 415 | 182 | 219 | 721 | 612 | 707 | 611 | 291 |
| True negatives | 2222 | 1074 | 754 | 399 | 2113 | 2101 | 1583 | 1636 | 1493 | 1841 | 1608 | 2381 | 1471 | 1185 | 3325 |
| False positives | 17 | 8 | 159 | 90 | 44 | 9 | 19 | 45 | 258 | 67 | 266 | 91 | 49 | 54 | 129 |
| Total (seconds) | 3201 | 3369 | 3338 | 3431 | 3524 | 3017 | 3265 | 2942 | 3353 | 2815 | 3415 | 3139 | 3387 | 3553 | 3819 |
| **sensitivity %** | **84.7** | **99.1** | **47.5** | **55.1** | **58.9** | **17.8** | **59.0** | **67.1** | **88.6** | **75.9** | **53.2** | **8.2** | **62.1** | **73.6** | **20.3** |
| **specificity %** | **99.2** | **99.3** | **82.6** | **81.6** | **98.0** | **99.6** | **98.8** | **97.3** | **85.3** | **96.5** | **85.8** | **96.3** | **96.8** | **95.6** | **96.3** |
| **positive predictive value %** | **98.0** | **99.6** | **87.9** | **94.7** | **94.8** | **94.7** | **98.1** | **94.9** | **84.6** | **91.1** | **75.5** | **37.7** | **95.9** | **96.9** | **36.5** |
| | | | | | | | | | | | | | | | |
| **Excluding all direct observation 'Other' seconds (i.e. excluding other, kneel up, crouch, crawl)** | | | | | | | | | | | | | | | |
| True positives | 815 | 2267 | 1151 | 1622 | 805 | 161 | 981 | 846 | 1420 | 688 | 820 | 55 | 1160 | 1703 | 74 |
| False negatives | 147 | 20 | 1274 | 1320 | 562 | 746 | 682 | 415 | 182 | 219 | 721 | 612 | 707 | 611 | 291 |
| True negatives | 2204 | 997 | 705 | 315 | 1988 | 2086 | 1261 | 1476 | 1408 | 1817 | 1547 | 2310 | 1419 | 1112 | 3242 |
| False positives | 16 | 8 | 81 | 14 | 16 | 1 | 15 | 10 | 251 | 64 | 101 | 84 | 49 | 54 | 122 |
| Total (seconds) | 3182 | 3292 | 3211 | 3271 | 3371 | 2994 | 2939 | 2747 | 3261 | 2788 | 3189 | 3061 | 3335 | 3480 | 3729 |
| **sensitivity %** | **84.7** | **99.1** | **47.5** | **55.1** | **58.9** | **17.8** | **59.0** | **67.1** | **88.6** | **75.9** | **53.2** | **8.2** | **62.1** | **73.6** | **20.3** |
| **specificity %** | **99.3** | **99.2** | **89.7** | **95.7** | **99.2** | **100.0** | **98.8** | **99.3** | **84.9** | **96.6** | **93.9** | **96.5** | **96.7** | **95.4** | **96.4** |
| **positive predictive value %** | **98.1** | **99.6** | **93.4** | **99.1** | **98.1** | **99.4** | **98.5** | **98.8** | **85.0** | **91.5** | **89.0** | **39.6** | **95.9** | **96.9** | **37.8** |

**Table 32 DynaPort MicroMod sit output against direct observation, child N0016-N0032**

| | N0001 | N0002 | N0003 | N0004 | N0005 | N0006 | N0007 | N0008 | N0009 | N0010 | N0011 | N0012 | N0013 | N0014 | N0015 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| True positives (sec) | 793 | 918 | 710 | 455 | 373 | 292 | 2157 | 2201 | 277 | 396 | 282 | 816 | 719 | 270 | 1321 |
| False negatives (sec) | 220 | 595 | 862 | 1046 | 250 | 211 | 1101 | 952 | 200 | 347 | 75 | 388 | 206 | 211 | 464 |
| True negatives (sec) | 1157 | 843 | 1489 | 1128 | 1427 | 1788 | 264 | 239 | 1333 | 1404 | 2843 | 974 | 2296 | 1737 | 1230 |
| False positives (sec) | 1095 | 960 | 91 | 403 | 306 | 700 | 89 | 49 | 2048 | 623 | 551 | 1208 | 361 | 454 | 167 |
| Sum (sec) | 3265 | 3316 | 3152 | 3032 | 2356 | 2991 | 3611 | 3441 | 3858 | 2770 | 3751 | 3386 | 3582 | 2672 | 3182 |
| **Sensitivity (%)** | **78.3** | **60.7** | **45.2** | **30.3** | **59.9** | **58.1** | **66.2** | **69.8** | **58.1** | **53.3** | **79.0** | **67.8** | **77.7** | **56.1** | **74.0** |
| **Specificity (%)** | **51.4** | **46.8** | **94.2** | **73.7** | **82.3** | **71.9** | **74.8** | **83.0** | **39.4** | **69.3** | **83.8** | **44.6** | **86.4** | **79.3** | **88.0** |
| **Positive predictive value (%)** | **42.0** | **48.9** | **88.6** | **53.0** | **54.9** | **29.4** | **96.0** | **97.8** | **11.9** | **38.9** | **33.9** | **40.3** | **66.6** | **37.3** | **88.8** |
| | | | | | | | | | | | | | | | |
| **Excluding all direct observation ‘Other’ seconds (i.e. excluding other, kneel up, crouch, crawl)** | | | | | | | | | | | | | | | |
| True positives (sec) | 793 | 918 | 710 | 455 | 373 | 292 | 2157 | 2201 | 277 | 396 | 282 | 816 | 719 | 270 | 1321 |
| False negatives (sec) | 220 | 595 | 862 | 1046 | 250 | 211 | 1101 | 952 | 200 | 347 | 75 | 388 | 206 | 211 | 464 |
| True negatives (sec) | 1145 | 839 | 1487 | 1116 | 1331 | 1726 | 254 | 234 | 1312 | 1378 | 2842 | 928 | 2170 | 1712 | 1170 |
| False positives (sec) | 1063 | 939 | 89 | 394 | 197 | 624 | 83 | 36 | 1995 | 458 | 540 | 1022 | 327 | 439 | 109 |
| Sum (sec) | 3221 | 3291 | 3148 | 3011 | 2151 | 2853 | 3595 | 3423 | 3784 | 2579 | 3739 | 3154 | 3422 | 2632 | 3064 |
| **Sensitivity (%)** | **78.3** | **60.7** | **45.2** | **30.3** | **59.9** | **58.1** | **66.2** | **69.8** | **58.1** | **53.3** | **79.0** | **67.8** | **77.7** | **56.1** | **74.0** |
| **Specificity (%)** | **51.9** | **47.2** | **94.4** | **73.9** | **87.1** | **73.4** | **75.4** | **86.7** | **39.7** | **75.1** | **84.0** | **47.6** | **86.9** | **79.6** | **91.5** |
| **Positive predictive value (%)** | **42.7** | **49.4** | **88.9** | **53.6** | **65.4** | **31.9** | **96.3** | **98.4** | **12.2** | **46.4** | **34.3** | **44.4** | **68.7** | **38.1** | **92.4** |

**Table 33 DynaPort MicroMod stand output against direct observation, child N0001-N0015**

| | N0016 | N0017 | N0018 | N0019 | N0020 | N0021 | N0023 | N0024 | N0025 | N0027 | N0028 | N0029 | N0030 | N0031 | N0032 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| True positives | 1489 | 263 | 427 | 153 | 667 | 347 | 487 | 210 | 1096 | 1161 | 944 | 188 | 666 | 848 | 1711 |
| False negatives | 244 | 39 | 157 | 56 | 403 | 248 | 243 | 308 | 343 | 295 | 326 | 500 | 284 | 172 | 764 |
| True negatives | 1291 | 2868 | 1454 | 1885 | 1840 | 1851 | 1626 | 1930 | 1662 | 1092 | 1388 | 1761 | 1677 | 1955 | 996 |
| False positives | 177 | 199 | 1300 | 1337 | 614 | 571 | 909 | 494 | 252 | 267 | 757 | 690 | 760 | 578 | 348 |
| Total (seconds) | 3201 | 3369 | 3338 | 3431 | 3524 | 3017 | 3265 | 2942 | 3353 | 2815 | 3415 | 3139 | 3387 | 3553 | 3819 |
| **Sensitivity (%)** | **85.9** | **87.1** | **73.1** | **73.2** | **62.3** | **58.3** | **66.7** | **40.5** | **76.2** | **79.7** | **74.3** | **27.3** | **70.1** | **83.1** | **69.1** |
| **Specificity (%)** | **87.9** | **93.5** | **52.8** | **58.5** | **75.0** | **76.4** | **64.1** | **79.6** | **86.8** | **80.4** | **64.7** | **71.8** | **68.8** | **77.2** | **74.1** |
| **Positive predictive value (%)** | **89.4** | **56.9** | **24.7** | **10.3** | **52.1** | **37.8** | **34.9** | **29.8** | **81.3** | **81.3** | **55.5** | **21.4** | **46.7** | **59.5** | **83.1** |
| | | | | | | | | | | | | | | | |
| **Excluding all direct observation 'Other' seconds (i.e. excluding other, kneel up, crouch, crawl)** | | | | | | | | | | | | | | | |
| True positives | 1489 | 263 | 427 | 153 | 667 | 347 | 487 | 210 | 1096 | 1161 | 944 | 188 | 666 | 848 | 1711 |
| False negatives | 244 | 39 | 157 | 56 | 403 | 248 | 243 | 308 | 343 | 295 | 326 | 500 | 284 | 172 | 764 |
| True negatives | 1278 | 2841 | 1372 | 1799 | 1757 | 1837 | 1581 | 1814 | 1635 | 1084 | 1215 | 1705 | 1677 | 1940 | 952 |
| False positives | 171 | 149 | 1255 | 1263 | 544 | 562 | 628 | 415 | 187 | 248 | 704 | 668 | 708 | 520 | 302 |
| Total (seconds) | 3182 | 3292 | 3211 | 3271 | 3371 | 2994 | 2939 | 2747 | 3261 | 2788 | 3189 | 3061 | 3335 | 3480 | 3729 |
| **Sensitivity (%)** | **85.9** | **87.1** | **73.1** | **73.2** | **62.3** | **58.3** | **66.7** | **40.5** | **76.2** | **79.7** | **74.3** | **27.3** | **70.1** | **83.1** | **69.1** |
| **Specificity (%)** | **88.2** | **95.0** | **52.2** | **58.8** | **76.4** | **76.6** | **71.6** | **81.4** | **89.7** | **81.4** | **63.3** | **71.8** | **70.3** | **78.9** | **75.9** |
| **Positive predictive value (%)** | **89.7** | **63.8** | **25.4** | **10.8** | **55.1** | **38.2** | **43.7** | **33.6** | **85.4** | **82.4** | **57.3** | **22.0** | **48.5** | **62.0** | **85.0** |

**Table 34 DynaPort MicroMod stand output against direct observation, child N0016-N0032**

| | N0001 | N0002 | N0003 | N0004 | N0005 | N0006 | N0007 | N0008 | N0009 | N0010 | N0011 | N0012 | N0013 | N0014 | N0015 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| True positives | 150 | 204 | 174 | 147 | 639 | 850 | 130 | 161 | 447 | 876 | 110 | 196 | 268 | 623 | 421 |
| False negatives | 57 | 85 | 36 | 45 | 123 | 210 | 32 | 43 | 175 | 146 | 14 | 71 | 100 | 136 | 187 |
| True negatives | 3014 | 2984 | 2915 | 2812 | 1495 | 1849 | 3375 | 3079 | 3182 | 1518 | 3592 | 3019 | 3166 | 1811 | 2498 |
| False positives | 44 | 43 | 27 | 28 | 99 | 82 | 74 | 158 | 54 | 230 | 35 | 100 | 48 | 102 | 76 |
| Total (seconds) | 3265 | 3316 | 3152 | 3032 | 2356 | 2991 | 3611 | 3441 | 3858 | 2770 | 3751 | 3386 | 3582 | 2672 | 3182 |
| **Sensitivity (%)** | **72.5** | **70.6** | **82.9** | **76.6** | **83.9** | **80.2** | **80.2** | **78.9** | **71.9** | **85.7** | **88.7** | **73.4** | **72.8** | **82.1** | **69.2** |
| **Specificity (%)** | **98.6** | **98.6** | **99.1** | **99.0** | **93.8** | **95.8** | **97.9** | **95.1** | **98.3** | **86.8** | **99.0** | **96.8** | **98.5** | **94.7** | **97.0** |
| **Positive predictive value (%)** | **77.3** | **82.6** | **86.6** | **84.0** | **86.6** | **91.2** | **63.7** | **50.5** | **89.2** | **79.2** | **75.9** | **66.2** | **84.8** | **85.9** | **84.7** |
| | | | | | | | | | | | | | | | |
| **Excluding all direct observation ‘Other’ seconds (i.e. excluding other, kneel up, crouch, crawl)** | | | | | | | | | | | | | | | |
| True positives | 150 | 204 | 174 | 147 | 639 | 850 | 130 | 161 | 447 | 876 | 110 | 196 | 268 | 623 | 421 |
| False negatives | 57 | 85 | 36 | 45 | 123 | 210 | 32 | 43 | 175 | 146 | 14 | 71 | 100 | 136 | 187 |
| True negatives | 2975 | 2959 | 2911 | 2795 | 1310 | 1721 | 3359 | 3064 | 3108 | 1347 | 3580 | 2792 | 3006 | 1775 | 2387 |
| False positives | 39 | 43 | 27 | 24 | 79 | 72 | 74 | 155 | 54 | 210 | 35 | 95 | 48 | 98 | 69 |
| Total (seconds) | 3221 | 3291 | 3148 | 3011 | 2151 | 2853 | 3595 | 3423 | 3784 | 2579 | 3739 | 3154 | 3422 | 2632 | 3064 |
| **Sensitivity (%)** | **72.5** | **70.6** | **82.9** | **76.6** | **83.9** | **80.2** | **80.2** | **78.9** | **71.9** | **85.7** | **88.7** | **73.4** | **72.8** | **82.1** | **69.2** |
| **Specificity (%)** | **98.7** | **98.6** | **99.1** | **99.1** | **94.3** | **96.0** | **97.8** | **95.2** | **98.3** | **86.5** | **99.0** | **96.7** | **98.4** | **94.8** | **97.2** |
| **Positive predictive value (%)** | **79.4** | **82.6** | **86.6** | **86.0** | **89.0** | **92.2** | **63.7** | **50.9** | **89.2** | **80.7** | **75.9** | **67.4** | **84.8** | **86.4** | **85.9** |

**Table 35 DynaPort MicroMod walk output against direct observation, child N0001-N0015**

| | N0016 | N0017 | N0018 | N0019 | N0020 | N0021 | N0023 | N0024 | N0025 | N0027 | N0028 | N0029 | N0030 | N0031 | N0032 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| True positives | 327 | 107 | 86 | 71 | 391 | 1183 | 253 | 813 | 152 | 287 | 206 | 1009 | 258 | 74 | 564 |
| False negatives | 160 | 51 | 112 | 49 | 166 | 303 | 155 | 145 | 65 | 138 | 168 | 690 | 252 | 72 | 325 |
| True negatives | 2645 | 3202 | 3128 | 3297 | 2700 | 1211 | 2756 | 1775 | 3094 | 2307 | 2986 | 932 | 2790 | 3374 | 2717 |
| False positives | 69 | 9 | 12 | 14 | 267 | 320 | 101 | 209 | 42 | 83 | 55 | 508 | 87 | 33 | 213 |
| Total (seconds) | 3201 | 3369 | 3338 | 3431 | 3524 | 3017 | 3265 | 2942 | 3353 | 2815 | 3415 | 3139 | 3387 | 3553 | 3819 |
| **Sensitivity (%)** | **67.1** | **67.7** | **43.4** | **59.2** | **70.2** | **79.6** | **62.0** | **84.9** | **70.0** | **67.5** | **55.1** | **59.4** | **50.6** | **50.7** | **63.4** |
| **Specificity (%)** | **97.5** | **99.7** | **99.6** | **99.6** | **91.0** | **79.1** | **96.5** | **89.5** | **98.7** | **96.5** | **98.2** | **64.7** | **97.0** | **99.0** | **92.7** |
| **Positive predictive value (%)** | **82.6** | **92.2** | **87.8** | **83.5** | **59.4** | **78.7** | **71.5** | **79.5** | **78.4** | **77.6** | **78.9** | **66.5** | **74.8** | **69.2** | **72.6** |
| | | | | | | | | | | | | | | | |
| **Excluding all direct observation 'Other' seconds (i.e. excluding other, kneel up, crouch, crawl)** | | | | | | | | | | | | | | | |
| True positives | 327 | 107 | 86 | 71 | 391 | 1183 | 253 | 813 | 152 | 287 | 206 | 1009 | 258 | 74 | 564 |
| False negatives | 160 | 51 | 112 | 49 | 166 | 303 | 155 | 145 | 65 | 138 | 168 | 690 | 252 | 72 | 325 |
| True negatives | 2627 | 3125 | 3001 | 3137 | 2573 | 1191 | 2433 | 1619 | 3013 | 2280 | 2760 | 883 | 2738 | 3307 | 2627 |
| False positives | 68 | 9 | 12 | 14 | 241 | 317 | 98 | 170 | 31 | 83 | 55 | 479 | 87 | 27 | 213 |
| Total (seconds) | 3182 | 3292 | 3211 | 3271 | 3371 | 2994 | 2939 | 2747 | 3261 | 2788 | 3189 | 3061 | 3335 | 3480 | 3729 |
| **Sensitivity (%)** | **67.1** | **67.7** | **43.4** | **59.2** | **70.2** | **79.6** | **62.0** | **84.9** | **70.0** | **67.5** | **55.1** | **59.4** | **50.6** | **50.7** | **63.4** |
| **Specificity (%)** | **97.5** | **99.7** | **99.6** | **99.6** | **91.4** | **79.0** | **96.1** | **90.5** | **99.0** | **96.5** | **98.0** | **64.8** | **96.9** | **99.2** | **92.5** |
| **Positive predictive value (%)** | **82.8** | **92.2** | **87.8** | **83.5** | **61.9** | **78.9** | **72.1** | **82.7** | **83.1** | **77.6** | **78.9** | **67.8** | **74.8** | **73.3** | **72.6** |

**Table 36 DynaPort MicroMod walk output against direct observation, child N0016-N0032**

| | N0001 | N0002 | N0003 | N0004 | N0005 | N0006 | N0007 | N0008 | N0009 | N0010 | N0011 | N0012 | N0013 | N0014 | N0015 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| True positives | 185 | 264 | 193 | 180 | 698 | 956 | 151 | 189 | 543 | 960 | 121 | 236 | 346 | 699 | 535 |
| False negatives | 22 | 25 | 17 | 12 | 64 | 104 | 11 | 15 | 79 | 62 | 3 | 31 | 22 | 60 | 73 |
| True negatives | 2754 | 2738 | 2752 | 2718 | 1233 | 1689 | 2715 | 2462 | 2961 | 1344 | 3494 | 2545 | 3016 | 1657 | 2203 |
| False positives | 304 | 289 | 190 | 122 | 361 | 242 | 734 | 775 | 275 | 404 | 133 | 574 | 198 | 256 | 371 |
| Total (seconds) | 3265 | 3316 | 3152 | 3032 | 2356 | 2991 | 3611 | 3441 | 3858 | 2770 | 3751 | 3386 | 3582 | 2672 | 3182 |
| **Sensitivity (%)** | **89.4** | **91.3** | **91.9** | **93.8** | **91.6** | **90.2** | **93.2** | **92.6** | **87.3** | **93.9** | **97.6** | **88.4** | **94.0** | **92.1** | **88.0** |
| **Specificity (%)** | **90.1** | **90.5** | **93.5** | **95.7** | **77.4** | **87.5** | **78.7** | **76.1** | **91.5** | **76.9** | **96.3** | **81.6** | **93.8** | **86.6** | **85.6** |
| **Positive predictive value (%)** | **37.8** | **47.7** | **50.4** | **59.6** | **65.9** | **79.8** | **17.1** | **19.6** | **66.4** | **70.4** | **47.6** | **29.1** | **63.6** | **73.2** | **59.1** |

| | N0016 | N0017 | N0018 | N0019 | N0020 | N0021 | N0023 | N0024 | N0025 | N0027 | N0028 | N0029 | N0030 | N0031 | N0032 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| True positives | 432 | 130 | 150 | 106 | 491 | 1331 | 356 | 898 | 200 | 370 | 290 | 1292 | 415 | 127 | 812 |
| False negatives | 55 | 28 | 48 | 14 | 66 | 155 | 50 | 60 | 17 | 55 | 84 | 407 | 95 | 19 | 77 |
| True negatives | 2443 | 3175 | 2989 | 3188 | 2444 | 933 | 2543 | 1535 | 3009 | 2128 | 2710 | 617 | 2540 | 3178 | 2185 |
| False positives | 271 | 36 | 151 | 123 | 523 | 598 | 316 | 449 | 127 | 262 | 331 | 823 | 337 | 229 | 745 |
| Total (seconds) | 3201 | 3369 | 3338 | 3431 | 3524 | 3017 | 3265 | 2942 | 3353 | 2815 | 3415 | 3139 | 3387 | 3553 | 3819 |
| **Sensitivity (%)** | **88.7** | **82.3** | **75.8** | **88.3** | **88.2** | **89.6** | **87.7** | **93.7** | **92.2** | **87.1** | **77.5** | **76.0** | **81.4** | **87.0** | **91.3** |
| **Specificity (%)** | **90.0** | **98.9** | **95.2** | **96.3** | **82.4** | **60.9** | **88.9** | **77.4** | **96.0** | **89.0** | **89.1** | **42.8** | **88.3** | **93.3** | **74.6** |
| **Positive predictive value (%)** | **61.5** | **78.3** | **49.8** | **46.3** | **48.4** | **69.0** | **53.0** | **66.7** | **61.2** | **58.5** | **46.7** | **61.1** | **55.2** | **35.7** | **52.2** |

**Table 37 DynaPort MicroMod [walk and shuffle] output against direct observation walk, child N0001-N0032**

**N0005**

| | Locomotion | Lying | Shuffling | Sitting | Standing |
|---|---|---|---|---|---|
| crawl | 1 | 0 | 1 | 2 | 8 |
| crouch | 2 | 0 | 14 | 0 | 13 |
| jump | 5 | 0 | 3 | 0 | 1 |
| kneel up | 12 | 0 | 33 | 3 | 41 |
| lie | 0 | 327 | 2 | 0 | 1 |
| other | 5 | 0 | 18 | 5 | 47 |
| run | 351 | 0 | 3 | 0 | 2 |
| sit | 10 | 26 | 40 | 216 | 144 |
| stand | 69 | 11 | 154 | 16 | 373 |
| walk | 283 | 9 | 53 | 3 | 49 |
| All All | 2356 | | | | |

**N0010**

| | Locomotion | Shuffling | Sitting | Standing |
|---|---|---|---|---|
| crouch | 1 | 1 | 0 | 93 |
| jump | 3 | 3 | 0 | 0 |
| kneel up | 3 | 4 | 0 | 50 |
| other | 16 | 1 | 0 | 22 |
| run | 542 | 6 | 0 | 2 |
| sit | 3 | 31 | 382 | 398 |
| stand | 207 | 137 | 3 | 396 |
| walk | 331 | 75 | 2 | 58 |
| All All | 2770 | | | |

**Table 38 Minitab summary data (seconds) for direct observation and DynaPort MicroMod: Child N0005, N0010**

Number of seconds in each DynaPort MicroMod output category according to direct each direct observation category for N0005 and N0010. These children had >5% direct observation seconds in ‘other’ categories.

**N0012**

| | Locomotion | Lying | Shuffling | Sitting | Standing |
|---|---|---|---|---|---|
| crawl | 0 | 0 | 0 | 5 | 11 |
| crouch | 1 | 0 | 4 | 6 | 4 |
| jump | 0 | 1 | 0 | 0 | 0 |
| kneel up | 2 | 1 | 1 | 0 | 138 |
| lie | 0 | 7 | 0 | 3 | 1 |
| other | 2 | 9 | 0 | 15 | 33 |
| run | 18 | 0 | 4 | 0 | 0 |
| sit | 27 | 64 | 208 | 379 | 994 |
| skip | 8 | 0 | 0 | 0 | 0 |
| stand | 68 | 0 | 261 | 59 | 816 |
| walk | 170 | 0 | 36 | 3 | 27 |

| All |
|---|
| All |
| 3386 |

**Table 39 Minitab summary data (seconds) for direct observation and DynaPort MicroMod: Child N0012**

Number of seconds in each DynaPort MicroMod output category according to direct each direct observation category for N0012. This child had >5% direct observation seconds in ‘other’ categories.

**N0023**

| | Locomotion | Lying | Shuffling | Sitting | Standing |
|---|---|---|---|---|---|
| crawl | 0 | 7 | 0 | 1 | 25 |
| crouch | 3 | 0 | 5 | 0 | 23 |
| jump | 27 | 0 | 0 | 0 | 0 |
| kneel up | 0 | 0 | 2 | 2 | 3 |
| lie | 0 | 91 | 0 | 0 | 47 |
| other | 0 | 21 | 3 | 1 | 230 |
| run | 79 | 0 | 0 | 0 | 2 |
| sit | 11 | 68 | 66 | 981 | 537 |
| stand | 87 | 2 | 139 | 15 | 487 |
| walk | 147 | 8 | 103 | 0 | 42 |
| All All | 3265 | | | | |

**Table 40 Minitab summary data (seconds) for direct observation and DynaPort MicroMod: Child N0023**

Number of seconds in each DynaPort MicroMod output category according to direct each direct observation category for N0023. This child had >5% direct observation seconds in ‘other’ categories.

**N0024**

| crouch | | | | jump | | |
|---|---|---|---|---|---|---|
| Locomotion | Shuffling | Sitting | Standing | Locomotion | Shuffling | Sitting |
| 0 | 0 | 0 | 1 | 10 | 3 | 0 |

| | kneel up | | | | lie | |
|---|---|---|---|---|---|---|
| Standing | Locomotion | Shuffling | Sitting | Standing | Locomotion | Shuffling |
| 3 | 6 | 3 | 8 | 26 | 0 | 0 |

| | | other | | | | run |
|---|---|---|---|---|---|---|
| Sitting | Standing | Locomotion | Shuffling | Sitting | Standing | Locomotion |
| 6 | 4 | 33 | 39 | 27 | 52 | 339 |

| | | | sit | | | |
|---|---|---|---|---|---|---|
| Shuffling | Sitting | Standing | Locomotion | Shuffling | Sitting | Standing |
| 15 | 0 | 4 | 5 | 59 | 846 | 351 |

| skip | | | | stand | | |
|---|---|---|---|---|---|---|
| Locomotion | Shuffling | Sitting | Standing | Locomotion | Shuffling | Sitting |
| 14 | 0 | 0 | 0 | 165 | 139 | 4 |

| | walk | | | | All |
|---|---|---|---|---|---|
| Standing | Locomotion | Shuffling | Sitting | Standing | All |
| 210 | 450 | 67 | 0 | 53 | 2942 |

**N0028**

| crawl | | | | | kneel up | |
|---|---|---|---|---|---|---|
| Locomotion | Lying | Shuffling | Sitting | Standing | Locomotion | Lying |
| 0 | 0 | 0 | 0 | 43 | 0 | 0 |

| | | | lie | | | | |
|---|---|---|---|---|---|---|---|
| Shuffling | Sitting | Standing | Locomotion | Lying | Shuffling | Sitting | Standing |
| 2 | 148 | 5 | 0 | 0 | 0 | 0 | 4 |

| other | | | | | run | |
|---|---|---|---|---|---|---|
| Locomotion | Lying | Shuffling | Sitting | Standing | Locomotion | Lying |
| 0 | 0 | 6 | 17 | 5 | 21 | 0 |

| | | | sit | | | | |
|---|---|---|---|---|---|---|---|
| Shuffling | Sitting | Standing | Locomotion | Lying | Shuffling | Sitting | Standing |
| 11 | 0 | 21 | 2 | 7 | 79 | 820 | 633 |

| stand | | | | | walk | |
|---|---|---|---|---|---|---|
| Locomotion | Lying | Shuffling | Sitting | Standing | Locomotion | Lying |
| 53 | 0 | 189 | 84 | 944 | 185 | 0 |

| | | | All |
|---|---|---|---|
| Shuffling | Sitting | Standing | All |
| 73 | 17 | 46 | 3415 |

**Table 41 Minitab summary data (seconds) for direct observation and DynaPort MicroMod: Child N0024, N0028**

Number of seconds in each DynaPort MicroMod output category according to direct each direct observation category for N0024 and N0028. These children had >5% direct observation seconds in ‘other’ categories.

**N0021**

| | Locomotion | Shuffling | Sitting | Standing |
|---|---|---|---|---|
| crouch | 3 | 2 | 0 | 8 |
| jump | 3 | 0 | 0 | 0 |
| lie | 0 | 0 | 0 | 6 |
| other | 0 | 1 | 8 | 1 |
| peddle | 112 | 128 | 6 | 81 |
| run | 228 | 23 | 0 | 14 |
| sit | 54 | 50 | 155 | 321 |
| stand | 151 | 97 | 0 | 347 |
| walk | 952 | 125 | 1 | 140 |
| All All | 3017 | | | |

**N0029**

| | Locomotion | Shuffling | Sitting | Standing |
|---|---|---|---|---|
| crouch | 10 | 9 | 7 | 10 |
| jump | 49 | 0 | 2 | 6 |
| lie | 3 | 0 | 0 | 4 |
| other | 19 | 11 | 0 | 12 |
| peddle | 111 | 94 | 13 | 63 |
| run | 147 | 59 | 11 | 50 |
| sit | 34 | 73 | 42 | 237 |
| skip | 12 | 0 | 0 | 1 |
| stand | 330 | 129 | 41 | 188 |
| walk | 782 | 223 | 30 | 305 |
| All All | 3117 | | | |

**Table 42 Minitab summary data (seconds) for direct observation and DynaPort MicroMod: Child N0021, N0029 (Including direct observation 'Peddle')**

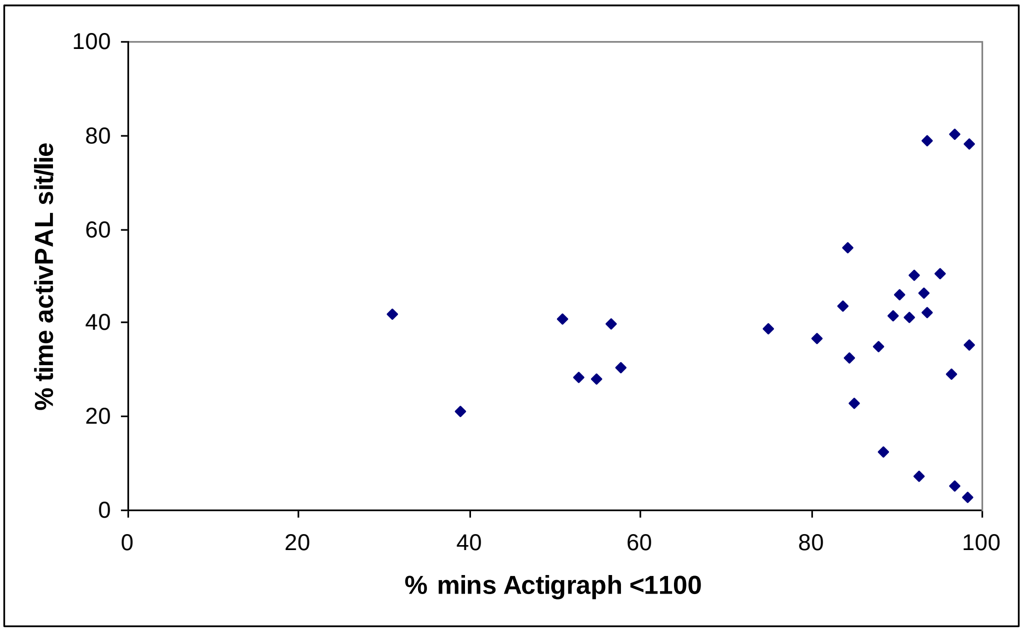
Number of seconds in each DynaPort MicroMod output category according to direct each direct observation category for N0021 and N0029. These children sat peddling on a tricycle during direct observation.

## 3.9 Sedentary behaviour assessment by the Actigraph , *activ*PAL™, and DynaPort MicroMod

Comparison was made between ActiGraph GT1M detected sedentary behaviours and output of the *activ*PAL™ and DynaPort MicroMod monitors. This allowed differentiation between sedentary behaviours defined on the basis of inactivity alone (as measured conventionally by the ActiGraph and validated for measurement of 'no translocation of the trunk' by Reilly(51)), or with the additional distinguishing factor of time spent sitting/lying. The cut off of <1100 counts/minute to define sedentary was used(51), and data from the total monitoring time (on and off screen) were used for analysis. The scatter plot of the proportion of time spent in *activ*PAL™ sit/lie output against the proportion of minutes spent sedentary as defined by the ActiGraph is shown in fig 29. Each child is represented by a single data point. Similarly, the proportion of time in *activ*PAL™ sit/lie and stand (combined) categories was plotted against the proportion of ActiGraph sedentary minutes. The proportion of ActiGraph defined sedentary minutes correlated significantly with *activ*PAL™ sit/lie and stand combined output (r=0.87, p <0.001) but poorly (r=0.16, p =0.413) with *activ*PAL™ sit/lie output alone.

The scatter plot of DynaPort MicroMod output against ActiGraph sedentary is shown in fig 30. Again, the proportion of ActiGraph defined sedentary minutes correlated with DynaPort MicroMod sit, lie and stand combined output (r=0.80, p<0.001), but less well (yet still significantly) with DynaPort output of sit and lie alone (r=0.39, p = 0.03).

### 3.9.1 Sedentary behaviour comparisons: figures



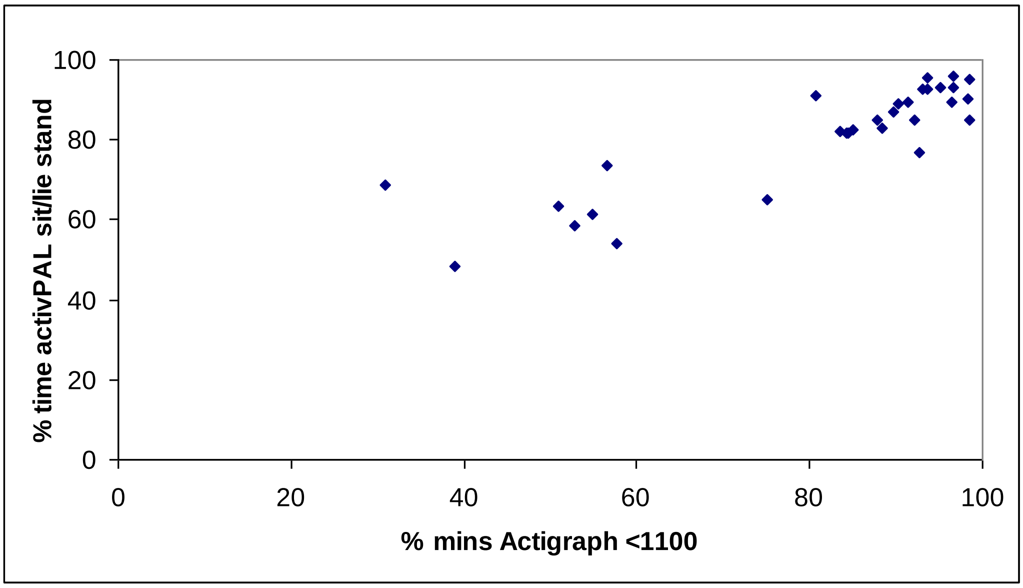
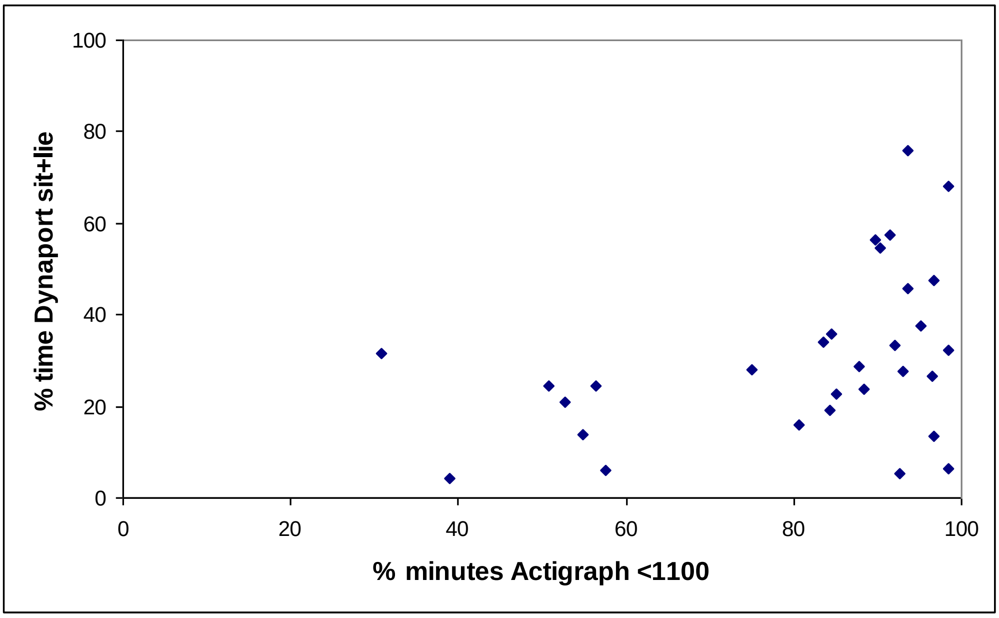




**Figure 29. Proportion of time in *activ*PAL$^{TM}$ output category against % ActiGraph defined sedentary minutes**

Top: Proportion of time in *activ*PAL$^{TM}$ output category sit/lie against proportion of minutes defined by ActiGraph counts as sedentary (<1100 counts/minute(51)),r = 0.16 (p=0.413). Bottom: Proportion of time in *activ*PAL$^{TM}$ output category sit/lie and stand against time spent sedentary as before, r = 0.87 (p<0.001).



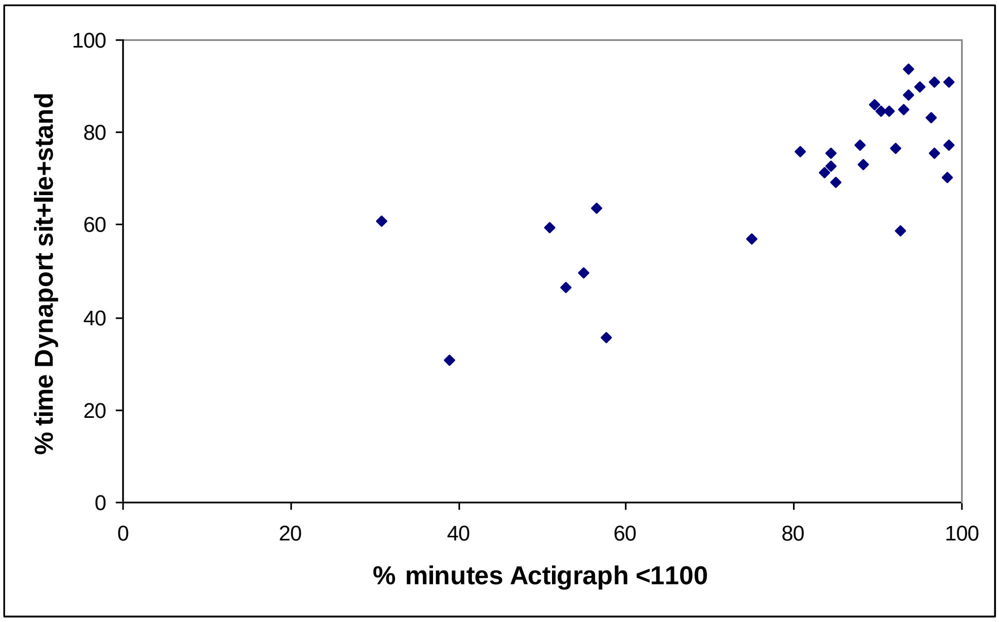




**Figure 30. Proportion of time in DynaPort MicroMod output category against % ActiGraph defined sedentary minutes**

Top: Proportion of time in DynaPort MicroMod output categories sit and lie against proportion of minutes defined by ActiGraph counts as sedentary (<1100 counts/minute(51)),r = 0.39 (p=0.03). Bottom: Proportion of time in DynaPort MicroMod output categories sit, lie and stand against time spent sedentary as before, r = 0.80 (p<0.001).

## 3.10 Posture transitions

Direct observation data were analysed by investigating the relationship between adjacent seconds on film to capture all posture transitions occurring on screen as described in Methods. All adjacent seconds were analysed, and transitions between seconds recorded according to direct observation category. Time spent either obscured or off screen during the monitoring period meant that the posture transitions between main direct observation categories captured are those appearing on screen only. Data were also analysed to compare the output of the *activ*PAL™ and DynaPort monitors during the longest uninterrupted period of filming as described, to allow comparison between direct observation, *activ*PAL™ and DynaPort MicroMod output categories.

The number of sit to stand or walk transitions during the observation period ranged from 1 to 46 per child. The posture transitions captured by the direct observation data demonstrate that in addition to sit stand, stand sit or stand walk etc. transitions, there were also a significant proportion of other-stand (including crouch stand, other stand, kneel up stand) transitions. The number of these transitions varied per child, as did the contribution of this type to transition to overall number of posture transitions during the observation period (table 43).

Raw data for each child are given in Appendix 5.5. For both the total measurement period and longest uninterrupted period of filming, results are presented in a format describing the relationship of all seconds within this period, and the total numbers of changes between categories (e.g. number of transitions between adjacent seconds with sit in the first second followed by stand in the next) are shown in grid tables. The left hand column defines the first second and top row the second for comparison. The number of on screen transitions between posture or activity is defined by non-matching observation category pairs. The longest uninterrupted time on screen varied from only a few minutes to almost the entire measurement time.

There was no relationship between the number of sit/lie to upright, or sit/lie/other to upright posture transitions and the proportion of time spent sedentary according to direct observation (figs 31 and 32). This is also illustrated in figure 33 with a plot according to rank order of number of posture transitions and proportion of time spent in sit/lie according to direct observation; rank order correlation coefficient (Spearman) r=0.087, p=0.649.

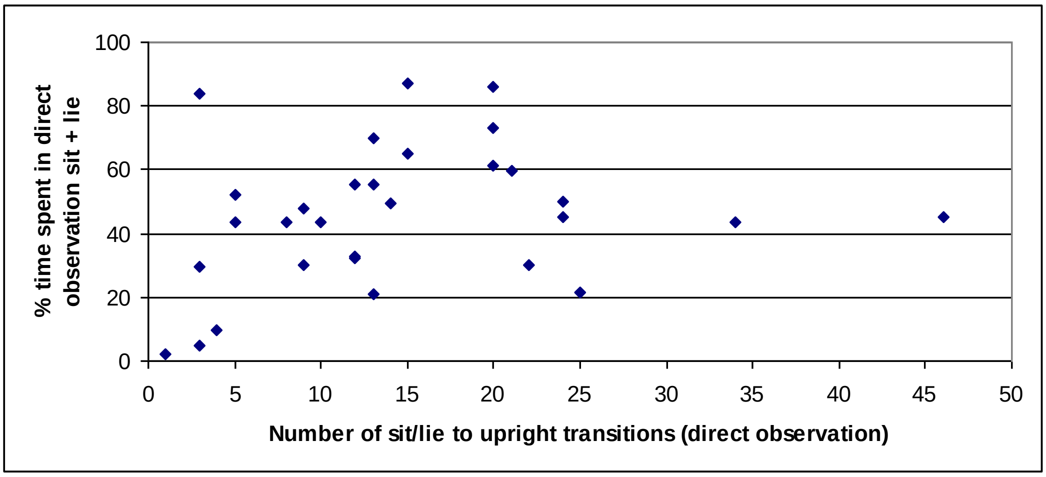
The number and type of direct observation transitions as compared with transitions detected by the *activ*PAL™ and DynaPort MicroMod during the longest uninterrupted period on screen are summarised in table 44 with results for each individual child in Appendix 5.6. The overall number of sit/lie to upright transitions captured by both the *activ*PAL™ and the DynaPort tended to overestimate the number of directly observed transitions occurring within the comparison period. The Wilcoxon matched pairs test for number of direct observation sit and lie to upright transitions vs. number of sit/lie to upright *activ*PAL™ transitions per child were significantly different ($p<0.0001$) both including and excluding 'other' to upright transitions on direct observation. Similarly, Wilcoxon matched pairs test for number of direct observation sit and lie to upright transitions vs. number of sit and lie to upright DynaPort MicroMod transitions per child were significantly different both including ($p<0.0005$) and excluding 'other' to upright transitions on direct observation ($p = 0.013$).

As shown in table 44, in some cases a large discrepancy was present between direct observation data and postural transitions captured by the *activ*PAL™ and DynaPort. For example, children N0007 and N0008 had no sit or lie to upright transitions on screen during the longest uninterrupted period on screen (they were both standing playing at the sandpit). However, both *activ*PAL™ and DynaPort detected multiple transitions during this period. When the on screen transitions included other to upright in addition to sit or lie to upright, some improvement was seen in the relationship between direct observation and *activ*PAL™ or DynaPort transitions. The monitors often interpreted [other to upright] transitions as [sit or lie to upright] transitions. Examples of the *activ*PAL™ and DynaPort sometimes capturing transitions accurately but at other times not doing so can been found in Appendix 5.4.

### *3.10.1 Posture transitions: tables and figures*

| | On screen sit/lie to upright transitions | Other to upright transitions | Total on screen sit/lie/other to upright |
|---|---|---|---|
| **N0001** | 20 | 5 | 25 |
| **N0002** | 46 | 5 | 51 |
| **N0003** | 8 | 2 | 10 |
| **N0004** | 5 | 3 | 8 |
| **N0005** | 12 | 13 | 25 |
| **N0006** | 34 | 15 | 49 |
| **N0007** | 3 | 2 | 5 |
| **N0008** | 1 | 9 | 10 |
| **N0009** | 13 | 7 | 20 |
| **N0010** | 3 | 14 | 17 |
| **N0011** | 15 | 1 | 16 |
| **N0012** | 24 | 17 | 41 |
| **N0013** | 21 | 2 | 23 |
| **N0014** | 5 | 7 | 12 |
| **N0015** | 13 | 2 | 15 |
| **N0016** | 9 | 1 | 10 |
| **N0017** | 3 | 3 | 6 |
| **N0018** | 20 | 4 | 24 |
| **N0019** | 20 | 1 | 21 |
| **N0020** | 14 | 19 | 33 |
| **N0021** | 22 | 9 | 31 |
| **N0023** | 13 | 13 | 26 |
| **N0024** | 10 | 21 | 31 |
| **N0025** | 9 | 8 | 17 |
| **N0027** | 12 | 2 | 14 |
| **N0028** | 24 | 1 | 25 |
| **N0029** | 25 | 20 | 45 |
| **N0030** | 12 | 8 | 20 |
| **N0031** | 15 | 6 | 21 |
| **N0032** | 4 | 4 | 8 |

**Table 43 Number of on screen posture transitions: Sit/lie to upright and ‘other’ to upright transitions, Child N0001-N0032**



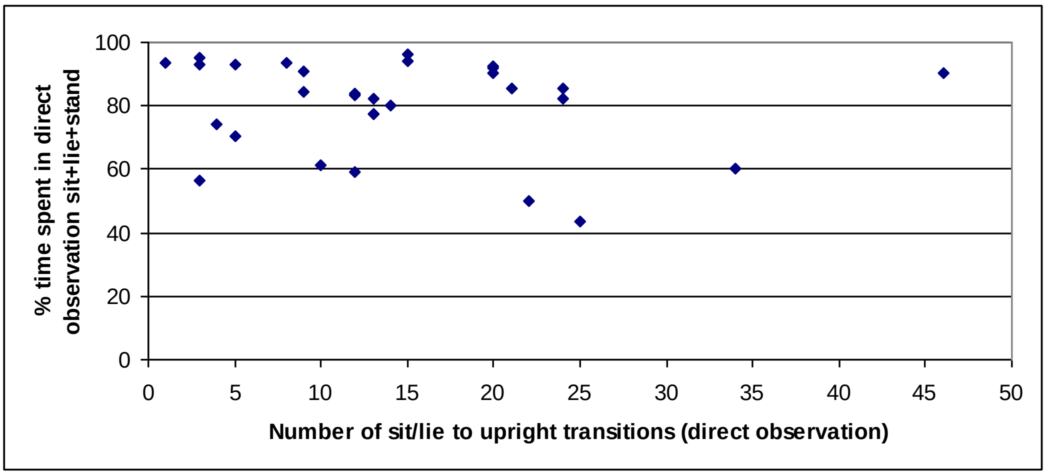




**Figure 31. Proportion of time sedentary and number of sit/lie to upright posture transitions**

Proportion of time spent in direct observation categories sit and lie (top) and sit, lie and stand (bottom) against total number of sit/lie to upright posture transitions during observation period. Each child is represented by a single data point.

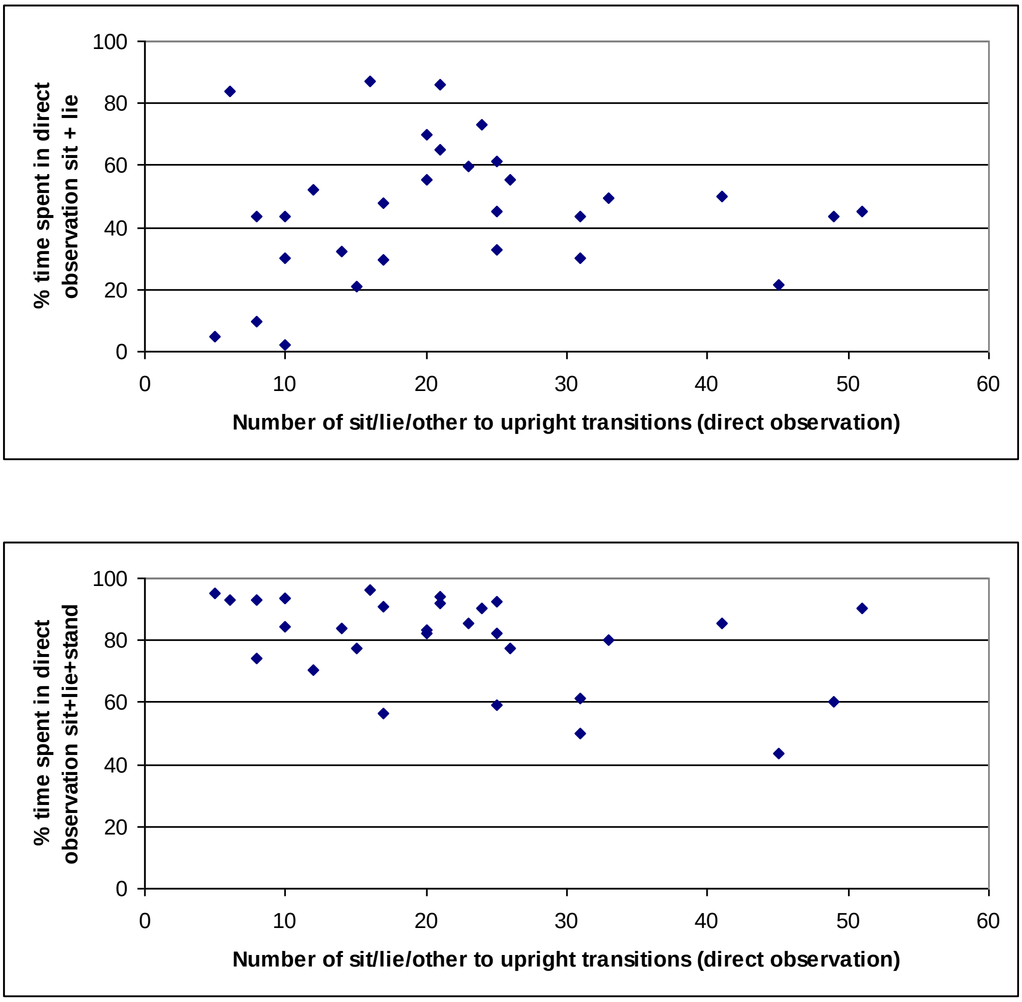
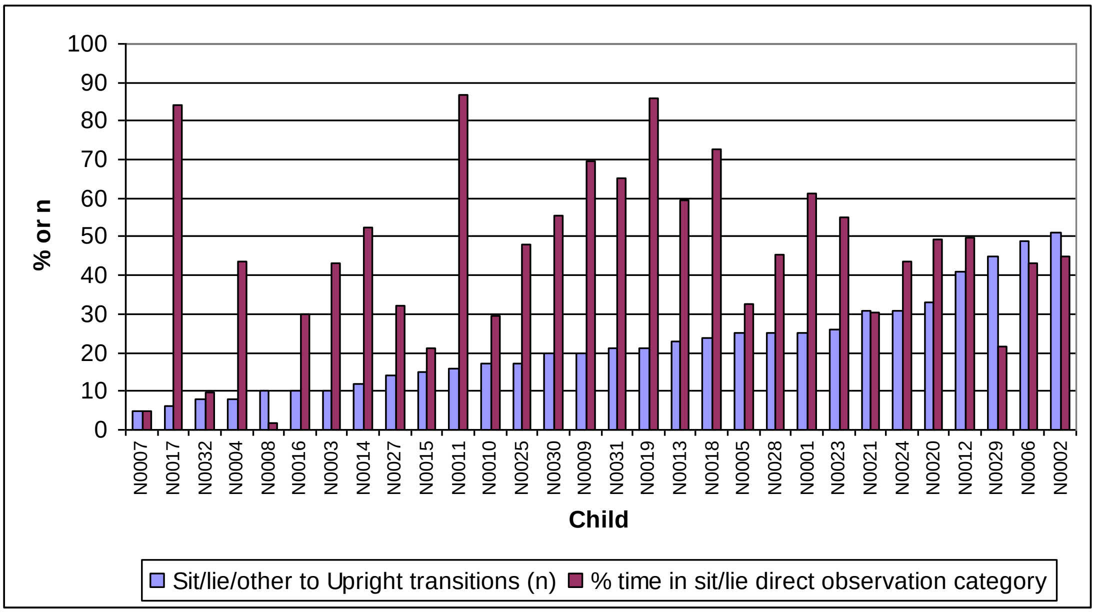



**Figure 32. Proportion of time sedentary and number of <u>sit/lie/other</u> to upright posture transitions**

Proportion of time spent in direct observation categories sit and lie (top) and sit, lie and stand (bottom) against total number of sit/lie or 'other' to upright posture transitions during observation period. Each child is represented by a single data point.



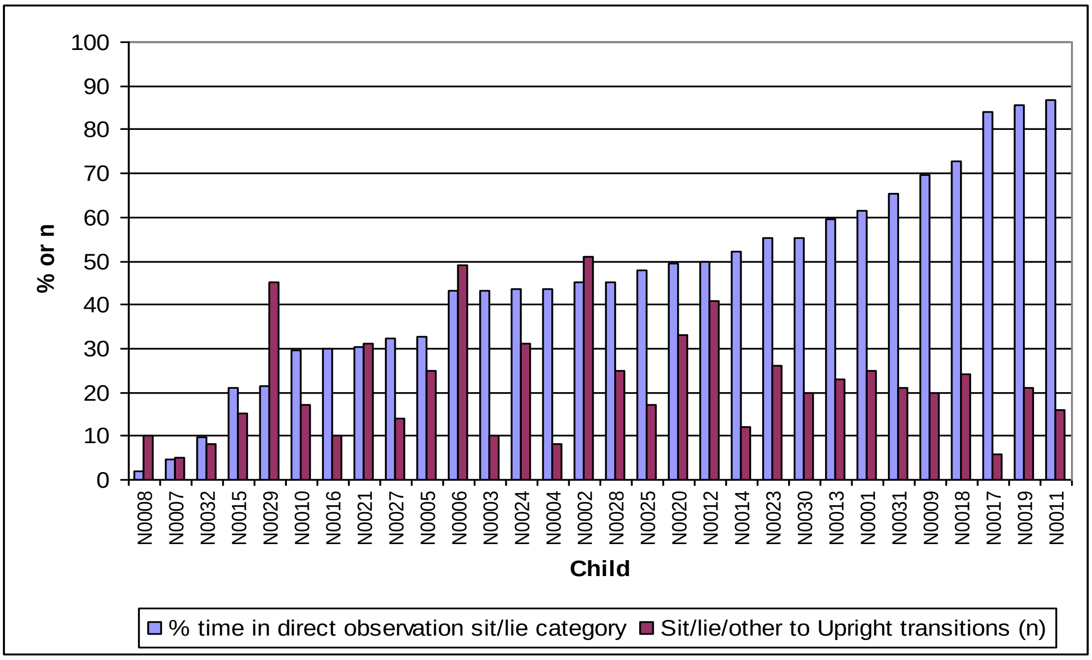




**Figure 33. Rank order plots according to time sitting and number of posture transitions**

Top: Ascending rank order plot according to number of sit, lie and 'other' to upright transitions plotted concurrently with proportion of time in sit and lie direct observation categories. Bottom: Ascending rank order plot of proportion of time spent sit and lie by direct observation, plotted concurrently with number of sit, lie and 'other' to upright posture transitions. Each child is represented on the x-axis. Spearman correlation coefficient r=0.087, p=0.649.

| Child | Longest uninterrupted observation section (seconds) | Direct observation sit or lie to upright transitions (n) | Direct observation total ‘other’ to upright transitions (n) | *activ*PAL™ sit/lie to upright transitions (n) | DynaPort sit or lie to upright transitions (n) |
|---|---|---|---|---|---|
| N0001 | 1720 | 14 | 0 | 30 | 15 |
| N0002 | 3309 | 45 | 5 | 50 | 27 |
| N0003 | 2734 | 6 | 0 | 6 | 9 |
| N0004 | 993 | 3 | 1 | 5 | 2 |
| N0005 | 705 | 2 | 3 | 8 | 6 |
| N0006 | 695 | 2 | 4 | 8 | 8 |
| N0007 | 3059 | 0 | 2 | 1 | 35 |
| N0008 | 2894 | 0 | 4 | 2 | 14 |
| N0009 | 1155 | 0 | 1 | 4 | 4 |
| N0010 | 271 | 0 | 0 | 0 | 0 |
| N0011 | 1195 | 0 | 0 | 0 | 3 |
| N0012 | 1206 | 3 | 9 | 11 | 15 |
| N0013 | 1670 | 0 | 0 | 4 | 4 |
| N0014 | 779 | 2 | 3 | 4 | 7 |
| N0015 | 577 | 0 | 0 | 1 | 4 |
| N0016 | 692 | 1 | 0 | 1 | 2 |
| N0017 | 760 | 1 | 3 | 8 | 2 |
| N0018 | 1302 | 14 | 2 | 28 | 9 |
| N0019 | 1472 | 8 | 0 | 5 | 9 |
| N0020 | 1151 | 1 | 5 | 5 | 2 |
| N0021 | 343 | 1 | 1 | 2 | 2 |
| N0023 | 832 | 1 | 1 | 14 | 11 |
| N0024 | 1020 | 2 | 3 | 6 | 8 |
| N0025 | 1042 | 0 | 1 | 0 | 2 |
| N0027 | 619 | 0 | 0 | 1 | 1 |
| N0028 | 843 | 2 | 0 | 11 | 9 |
| N0029 | 373 | 2 | 0 | 2 | 3 |
| N0030 | 1344 | 2 | 0 | 6 | 5 |
| N0031 | 1786 | 11 | 0 | 46 | 19 |
| N0032 | 1572 | 1 | 1 | 2 | 2 |

**Table 44 Posture transitions within longest uninterrupted section: Direct observation vs. *activ*PAL™ and DynaPort, child N0001-N0032**

Duration (in seconds) of longest uninterrupted section of direct observation data for each child is shown. Number(n) of sit/lie to upright and other to upright transitions on direct observation, in comparison to sit/lie to upright transitions detected by *activ*PAL™ and sit or lie to upright transitions detected by the DynaPort MicroMod during this period.

## 3.11 Short term practical utility of the two monitors

The monitors were in general very well tolerated in the present study. In fact often was the enthusiasm for wearing the monitors such that children would ask if it was their turn to wear them that day. In addition, not only the child wearing the monitors, but also their classmates would come up and touch the monitors. The *activ*PAL™ monitor was touched most often by the children. It was touched most frequently at the beginning of the observation period, and when children were sitting down listening to a story etc. This happened to a far lesser extent with the DynaPort MicroMod (in its neoprene belt) or ActiGraph, however several children lifted up their jumper or clothing to show teachers or friends the DynaPort belt. Children appeared to be fascinated by how the *activ*PAL™ monitor was sticking to their leg. Two children (N0020 and N0030) took the *activ*PAL™ monitors off their leg (being inquisitive) and had the monitor replaced by the researcher. Both had been touching frequently / showing friends / etc. prior to pulling them off. The monitors were both re-sited by the researcher and the observation period continued. Neither child took off the DynaPort or ActiGraph monitor. No child in the study complained when the *activ*PAL™ was being taken off their thigh – none suggested or expressed it was painful or in any other way uncomfortable. No local skin adverse reactions were seen. Child N0022 who did not want to wear the *activ*PAL™ decided this on feeling the sticky gel pad prior to it being applied to her thigh.

No impression was gained of limitation to usual activity whilst wearing the monitors. Children participated along with their classmates fully in their usual activity, wore the monitors including whilst on outdoor playground equipment, and in the case of one child during a gym lesson. Children in this study wore all three monitors (*activ*PAL™, DynaPort MicroMod and ActiGraph GT1M) and were filmed at the same time so it can not be known from these results how each monitor would be tolerated if each was worn individually and no filming took place, and the long term practical utility of the DynaPort and *activ*PAL™ monitors in free-living conditions is the subject of a separate study.

Filming the children on a single hand held camera was taken by several children as a novelty, and some wanted to deliberately appear in the screen, obscuring the view of the child intended to be filmed and interrupting their on screen time. Two children (N0032 and N0011) did not want to wear all three monitors for the entire videoed period as discussed previously. Both children wore the monitors on a second occasion to complete data collection.

# 4 Discussion

## 4.1 Overview of chapter and main study findings

The study described in this thesis has investigated the validity of the *activ*PAL™ and DynaPort MicroMod MoveMonitor algorithms in detecting posture and activity in pre-school children, using direct observation as the criterion measure. From direct video observation, the mean proportion of time spent during the one hour of video recording was sit/lie 46%; stand 35%; and walk 16%. The remaining 3% of time was spent in non-sit/lie/upright postures (e.g. crawl, crouch, kneel up) although transitions involving these contributed disproportionately to total posture transitions. The number of sit to stand posture transitions on direct observation was not associated with time spent sedentary. Overall sensitivity for time detected as *activ*PAL™ sit/lie was 87%, specificity 97% and positive predictive value 96%. DynaPort MicroMod sensitivity for sit was lower (61%) but specificity remained high (91%). Neither the *activ*PAL™ nor DynaPort MicroMod reliably detected the number of postural transitions in comparison to direct observation.

This chapter discusses the methodology and results of the validation study described in this thesis, how it relates to the literature and the relevance of issues raised for future validation work in this field.

Appropriate measurement sensors suitable for use in the pre-school child should take account of an understanding of the nature of childhood activity and movement. This should be accompanied by efforts to validate novel systems in the free-living environment rather than the laboratory setting. Developing the potential to understand better sedentary behaviours in young children is an exciting prospect for childhood obesity research.

## 4.2 Childhood direct observation physical activity rating scales and definitions of sedentary behaviour

Of the many approaches to measuring activity in young children, direct observation provides the most direct, practical and appropriate method. As such it is considered as the gold standard measure of physical activity (35).

However, in order to be able to quantify and interpret the observations, rating scales are required. Several direct observation rating systems have been designed to capture childhood physical activity behaviour and patterns. Activity is coded by these scales into a number of defined categories. The sampling time over which activity data is captured varies between rating scales from a few seconds to a minute (41;79). The currently available direct observation rating scales such as the Children's Physical Activity Form (CPAF) do not make any distinction between sitting and standing postures (41) and are aimed at quantifying gross body movement rather than posture. For example, the CPAF categorises activity in to one of four categories: stationary, no movement; stationary, limb movement; slow trunk movement (e.g. walking); and rapid trunk movement (e.g. running). Similarly, the System for Observing Play and Leisure Activity in Youth (SOPLAY)(40), Children's Activity Rating Scale (CARS)(42) and Studies of Children's Activity and Nutrition: Children's Activity Time sampling Survey (SCAN CATS)(80) do not record postural information as part of their classification systems. As with the CPAF, this means that 'sedentary' categories defined using these direct observation systems can include time when a child is both standing and sitting or lying. They essentially measure lack of movement rather than genuinely sedentary behaviour.

Direct observation rating systems which include categories that can differentiate on the basis of posture in addition to activity intensity include the Activity Patterns and Energy Expenditure (APEE)(43), Behaviours of Eating and Physical Activity for Children's Health Evaluation System (BEACHES)(38), System for Observing Fitness Instruction Time (SOFIT)(39), Fargo Activity Time sampling Survey (FATS)(37) and the Level and Tempo of Children's Physical Activity (LET0)(79). These also all use time sampling techniques to capture physical activity observational data within a defined range of categories. For example, the activity categories for APEE are sitting/lying quietly, standing quietly, sitting/lying while active, standing while active, and very active/moving. The categories for BEACHES are lying, sitting, standing, walking and very active. This rating scale involves a 25 second observation and 35 second recording period to produce a one minute observe-record cycle for data collection. Depending on the rating scale used, an assigned physical activity category may represent all activity occurring at any time over the sampling period (partial interval time sampling) or activity only at the end of each observed interval (momentary time sampling) over a specified time period. Regardless of whether a partial or momentary time sampling technique is employed, these direct observation scales do not enable the accurate capture of total postural transitions over a period of time nor provide a suitable gold standard against which validation of activity monitors with a posture detection capability can be assessed. Summary over a period of time also introduces error if there can only be one posture or activity recorded in each time sample as occurs with momentary time sampling. In summary, no currently available direct observation systems are designed for capturing ‘gold standard’ postural information in children and so in the present study postural data were obtained from direct observation by a second-second categorisation made by the author.

To date, traditional (non-posture detecting) accelerometers in childhood including the Actigraph and the Caltrac® accelerometer have been investigated against direct observation rating scales that categorise childhood activity according to activity intensity (37;42;51). As these accelerometers do not measure posture, the use of such rating scales was appropriate. ActiGraph cut-offs for ‘sedentary behaviours’ in young children have been defined according to CPAF category as minutes spent in CPAF 1 (stationary, no movement) and 2 (stationary with limb movement but no trunk movement) by Reilly et al (51). Results presented in this thesis have shown that the proportion of time spent in the *activ*PAL™ categories of sit/lie and stand correlated well with the proportion of minutes in ActiGraph defined sedentary minutes, according to this CPAF defined cut off of <1100cpm proposed by Reilly (51). However, interestingly, this relationship was lost in the present study when ActiGraph detected sedentary behaviours were plotted against *activ*PAL™ sit/lie output alone (Results Chapter section 3.9). Similar results were seen for the DynaPort MicroMod.

Although plotting proportion of time for *activ*PAL™ or DynaPort output category (with an output per second) against total minutes in a sedentary category as measured by the ActiGraph has its own limitations, the poor correlation between ActiGraph sedentary and *activ*PAL™ sit/lie in the present study suggests that the monitor can detect sedentary behaviours, in particular time sitting, beyond the capabilities of the ActiGraph in early childhood. This has potential implications for the research community investigating sedentary behaviours. In particular, the ActiGraph is widely used as a physical activity outcome measure in obesity research in childhood. However, even with this commonly used accelerometer, there is a lack of consensus about appropriate cut offs for activity intensity including sedentary behaviour (47). These cut offs change the proportion of activity identified as sedentary, as shown in the Results chapter with comparisons between minutes spent sedentary when using the definition by Reilly (51) and by Puyau et al (50). Interestingly the ActiGraph cut off to define time as sedentary was applied according to CPAF scale by Reilly, and according to activity related energy expenditure by room calorimetry by Puyau. It is possible that by using a different objective measure of sedentary behaviour (which includes posture) a reliance purely on accelerometry counts (and therefore cut offs) would not be necessary. There is not yet evidence to support a widespread change in type of activity monitor used to collect objective evidence of sedentariness as the implications of this additional detection capability have not been investigated. Particularly for child obesity research, there is a need to address what is important to measure (in terms of energy expenditure and outcome risk). If sitting behaviours are important to the energy balance equation, it is important that data collection (whether observational or objectively measured) includes specifically defines sedentary time as time sitting as opposed to inactive alone.

## 4.3 Direct observation tools in the wider literature

In the study described in this thesis, direct observation information was recorded on a second by second basis according to thirteen categories, which were then grouped into ‘sit/lie’, ‘stand’, ‘walk’, and ‘other’ for comparison analyses. These categories were similar to the output algorithms for the analysed *activ*PAL™ and DynaPort data files (with the exception of ‘other’ which is discussed below). In the literature, studies that have validated activity monitors including postural information have used a similar methodology for categorising postural information from direct observation. For example, the *activ*PAL™ validation study in adults categorised all direct observation data as either sitting, standing or walking on a second by second basis (73). However, this approach whereby the categories of comparison are the same as the output categories of the monitor may be an artificial oversimplification, particularly in the context of the free-living child's environment where the range of activities and postures is great.

Although not used in the field of physical activity research and child obesity, methods of analysing direct observation data for subject posture are used in the field of ergonomics and occupational health medicine. Several methods and rating scales have been developed to capture direct observation data in order to measure exposure to work place risk of musculoskeletal injury (81;82;82-86). One example, the Portable Ergonomic Observation (PEO) method, records real time recording of posture by an observer continuously recording posture and activity (including manual handling) on a computer (82). Observers record posture at the arm, neck, trunk and knee. The categories are based around those body regions associated with risk of work place injury. The PEO has been used in childhood to investigate sitting habits in children (87) and the influence of different school environments on sitting behaviours (88). PEO categories included static sitting, dynamic sitting (with dynamic sitting defined as sitting with continuous movement around the centre of gravity), sitting with and without use of a back rest, reading or writing, standing, walking around, being active (skipping, dancing, running), being on the floor (including lying or sitting on the floor), trunk flexion >20° and >45°, trunk rotation >45°, neck flexion >20° and neck rotation >45° (87).

These examples from the ergonomics literature may be important to consider (in terms of methodology) for future validation studies of objective posture measurement techniques in physical activity research. Physical activity monitors capable of detecting posture have tended to be validated by documentation of posture and activity on video recordings or in real time by an observer, without the use of particular reference tool beyond simple definitions of e.g. sitting. Body position has been summarised into limited posture categories which can generally be classed as 'up' (walk or stand) and 'down' (sit and lie), in order that outcomes such as the number of e.g. sit to stand transitions or time spent sitting can be quantified. However, as the results presented in this thesis show, it may be important to be able to quantify a wider group of postures by direct observation (and hence utilise experience from the ergonomics literature) in future studies of posture measurement methodology in young children. Although the angle of the trunk or neck may be beyond the detail required for physical activity research pertaining to ultimate data collection in the free living environment, greater detailing of human movement than carried out during this study or reported in the literature for similar validation studies may be important in further validation of objective posture detection methods. It will be helpful to establish a consensus regarding the acceptable summary classification for all ‘in between’ postures (e.g. kneel up), or aid decision making regarding acceptable error created by misclassification of these. Furthermore, by greater detail in recording of direct observation data, it will be possible to determine whether a single unit monitor for posture detection can ever be capable of collecting the array of activity performed by young children.

In the study presented in this thesis, postures not considered stand, walk, sit or lie were considered under the global term ‘other’, representing those seconds identified as crouch (squat), kneel up, crawl and other (requiring a diagram to define, Methods Chapter section 2.7.1, figure 6) in one heterogeneous category. This category was considered necessary because certain postures, for example kneel up or crouch, could not in the author’s opinion be placed comfortably within a definition of either sit or stand. However, by keeping this category separate, it meant that direct comparison with output categories from the *activ*PAL™ and DynaPort MicroMod would be more challenging as like categories could not always be directly compared with like. For example, when considering the specificity and positive predictive values for the *activ*PAL™ output of sit/lie in comparison to direct observation, should all seconds detected by the *activ*PAL™ as sit/lie when the child was actually crouching have been considered false positive, or should comparisons have been made purely comparing output during direct observation of more ‘standard’ postures such as sit, stand or lie. For the purposes of validation, both scenarios were considered important and therefore sensitivities, specificities and positive predictive values were calculated for each monitor output category for both the *activ*PAL™ and the DynaPort including and excluding all ‘other’ seconds for each child in the present study. Because the total number of seconds spent in 'other' postures was small in relation to the total monitored time per child, this did not have a substantial impact on specificity or predictive value. However, even though the total proportion of time spent in them per child was small, they accounted for a significant proportion of total posture transitions. For some children, there were more transitions between these other categories and standing and traditional sit stand transitions. The problem of classifying 'other' postures may therefore be greater for future measurement of posture transitions (which might be a useful proxy for fidgeting), than for measurement of posture *per se*.

For validation studies, it is important to use direct observation strategies that have the potential to capture body position however unusual, and irrespective of the duration that this posture may be sustained for. By concentrating on direct comparisons between the same direct observation categories as monitor output category, a researcher is not in a position to accurately be able to detect the true number of false positive or true negative seconds in that population.

## 4.4 Postural transitions and sedentary behaviours

Interestingly, some children in the present study with almost all their time spent sedentary had frequent posture transitions from sit to stand. For example, child N0002 had 46 sit to upright transitions during her observation period. She spent 96.4% of minutes sedentary (<1100 counts per minute) as defined by Actigraph counts and 90.6% of on screen time in [sit/lie] and [stand] direct observation categories. This example suggests that quantifying activity data on the basis of being sedentary, as defined by total time spent [sit/lie] and [stand] alone, misses an opportunity for data capture of any postural transitions between direct observation categories occurring during this time. It is possible that sedentary behaviour might be captured reasonably accurately, but that by assessing sedentary behaviour alone a potentially important construct of fidgeting (61;89) might be missed. In the present study no relationship existed between the proportion of time spent in direct observation categories of [sit and lie], or [sit/lie and stand] with the number of [sit/lie to upright] (including [sit/lie/other] to [upright]) transitions during the observation period. The rank order plots of proportion of time sedentary with number of posture transitions also illustrated the range in number of transitions over a relatively short measurement time and suggest that this could be an interesting outcome measure to investigate differences between groups in the future.

If posture transitions are important in childhood obesity risk (and conversely to investigate any potential relationship regarding this potential risk) rather than cumulative time spent sedentary, then continuing efforts to find valid objective measurement systems is important. It may be that an adjustment factor for sitting time taking account of number of transitions could be developed to integrate these two components and used as a potential novel measure to investigate differences between populations, such as obese and non obese children. Children with frequent transitions yet spending a large proportion of time sedentary may be 'fidgeters'. This could explain potential differences in non-exercise activity thermogenesis between groups of children, as Levine has suggested that fidgeting may be an important source of inter-individual variation in energy expenditure (89). Thus number of posture transitions may be a proxy measure for fidgeting. In terms of non-exercise activity in childhood, young children spend a low proportion of their time in moderate or vigorous physical activity(32) and therefore considering impact of posture transitions during sedentary time may be important in their energy balance equation.

The 'normal' number of daily posture transitions undertaken during usual activity for pre-school children is not known. However, activity undertaken by children is often of brief duration and therefore it is likely that posture transitions are common. Bailey et al studied fifteen children aged between six and ten years and found an average duration of six seconds for low and medium intensity activity (79). The normal number of daily of sit to stand posture transitions in adulthood is also largely unknown. McLeod et al observed nine adult subjects and found the number of sit to stand transitions was between 3 and 9 per hour. To calculate a daily average number of transitions hourly periods of data capture were combined and extrapolated, with the result suggesting that the average number of sit stand transitions per day was ninety two (90). Using a different methodological approach, a recent study by Dall et al has used the *activ*PAL™ to quantify the number of daily sit to stand transitions in a healthy adult population (91). This study involved 140 adults and found that the average number of transitions per day was 60 (±22 standard deviation) sit to stand posture transitions each day (the actual range was 10 to 124 transitions). When the effect of occupation and environment were studied, it was found that people whose occupation was indoors and considered largely sedentary had more sit to stand transitions than outdoor workers. Interestingly, the median number of sit to stand transitions performed in a single hour was three (range 0-43), and 21% of analysed hours had zero sit to stand transitions. As no direct observation accompanied data collection, it is unknown how many of these posture transitions actually represented posture transitions that would have been considered 'other to stand' in the study described in this thesis, such as a crouch stand transition or kneeling up one knee.

Consideration of whether [sit to other] (e.g. [sit to kneel up]) posture transitions are equivalent in terms of energy expenditure to 'half' a [sit to stand] transition, and whether any subsequent [kneel up to stand] transition is then captured as a further transition by an objective monitoring system will be useful when investigating the energy cost of (and importance of capturing) such transitions in future studies.

Comparison between the number of posture transitions on direct observation against *activ*PAL™ or DynaPort output during a period of uninterrupted child view presented in the Results chapter demonstrated a poor correlation for transitions between direct observation and monitor output. The monitors' ability to capture or miss postural changes in pre-school children suggests that currently the potential for the *activ*PAL™ or DynaPort to be able to accurately measure the number of transitions occurring is probably beyond their technical capability. Alternatively, it may have been that in the present study direct observation data were not coded with sufficient detail particularly with respect to trunk position whilst standing. For example, flexion of the trunk whilst standing playing may have been detected as [stand sit] transitions and could explain why child N0007 and N0008 had very discrepant number of transitions between direct observation data and DynaPort output. They spent almost their entire observation period standing playing at the sandpit.

With an acceptable methodology, the further development of single unit systems and signal analysis algorithms, posture transitions could be a useful outcome measure in the investigation of obesity risk in childhood. There is a body of evidence supporting the association of self reported sedentary behaviours with obesity and associated metabolic syndromes in adults (60;92-94) often using proportion of time spent viewing television as a surrogate marker of time spent sitting. As suggested by Healy et al (95), there is a need to understand more about the composition of total sedentary time and its association with risk. Healy investigated the relationship between breaks in objectively measured sedentary time with waist circumference, lipid, blood pressure and glucose metabolism in 168 adults. Sedentary behaviour was objectively quantified by accelerometry (ActiGraphs) according to an arbitrary cut off of <100 counts per minute (96) with any increase over this threshold (minimum one minute) when sedentary considered a break in sedentary time. They found that, independent of total sedentary time, breaks in sedentary time were associated with lower waist circumferences, BMI, triglycerides and lower plasma glucose levels following an oral glucose tolerance test. Healy et al suggest that generation of ActiGraphs counts of above 100 during sedentary time could be due to a transition from sit to stand, however no postural information is provided by the standard ActiGraph and so the role of postural transitions in such metabolic risk remains to be investigated - no objective posture detection systems were used in the study by Healy et al (95). This novel use of change in ActiGraph counts during sedentary periods as a proxy measure for true postural transitions has potential value, but needs to be validated, both in adult and child populations.

## 4.5 Measuring posture with single unit sensors in pre-school children

The most appropriate objective system for objectively measuring postural information in a free-living situation will depend on a number of factors: the population, the environment in which they will be used, and the practical utility of the monitoring system itself. There is unlikely to be a ‘one size fits all’ system; the optimal monitor to address one research question may be inappropriate to answer another. In early childhood, practical utility is particularly important. Simple, lightweight, non-cumbersome measuring systems that do not interrupt usual activity are required. Small body worn single unit monitors may be a practical option for research involving the pre-school child. Two independent single unit systems, the *activ*PAL™ and the DynaPort MicroMod with MoveMonitor algorithms have not been previously validated in pre-school children.

The results presented in this thesis show that both the *activ*PAL™ and DynaPort MicroMod are able to capture postural information in this age group fairly successfully, but wide variations were seen in their accuracy between different children. Overall, the sensitivity, specificity and positive predictive values for the *activ*PAL™ outputs were encouraging. Although overall results are less good than the adult *activ*PAL™ validation study performed by Grant et al (73), several key differences in methodology (aside from any differences between young children and adults) exist. Grant validated the *activ*PAL™ against direct observation in ten adults in a test room equipped with a treadmill, chair and utensils to assess activities of daily living. Their study had two components; the first assessed sitting, walking and standing in a controlled manner. Sitting and standing postures and walking on a treadmill were maintained for between two and nine minutes. In the second, utensils and equipment required to carry out a predetermined list of activities of daily living were laid out in the test room and subjects were asked to undertake a selection of tasks (such as removing clothes from a washing machine and hanging them on a clothes rack, preparing a drink, making a telephone call, changing a bulb in a table lamp, and reading a newspaper) without instruction on how to perform each task. Grant et al. state that 'further processing of the data produced a second by second output identifying the participant as either sitting/lying, standing or walking'. No description is made of any difficulty in categorising each posture into one of these three categories. They reported an identical number of transitions between observer and *activ*PAL™ monitor output, and overall agreement between *activ*PAL™ output and direct observation during controlled sitting, standing and walking of 98.5% and an overall agreement of 93.6% during activities of daily living (ADL). The sensitivity for *activ*PAL™ sitting was 99.4% (predictive value 99.5%), standing 84.9% (predictive value 88%) and for walking 67.4% (predictive value 63.7%) during their 'ADL' validation section of the study. The authors commented that short single steps, classified by an observer as walking, were not always detected by the monitor and conversely short 1-2 second pauses (standing) during walking were interpreted as a continuous walk. Results presented in this thesis give an overall sensitivity for sit/lie of 87% with positive predictive value of 96% when total seconds for each child were combined. However, unlike the adult study, we found a wide range of agreements between *activ*PAL™ and direct observation between children. Whereas for some children the *activ*PAL™ monitor was excellent at detecting time spent in different postures, for others there was substantial mismatch, particularly with time spent sitting misclassified as standing. For example, child N0016 had 45% sensitivity for *activ*PAL™ sit/lie (but positive predictive value of 99%) yet for twelve children the *activ*PAL™ sit/lie sensitivity was above 95%. The overall (total combined) sensitivity for *activ*PAL™ stand was 92%, which is greater than that reported in the adult study. However, again variation was seen between children with the *activ*PAL™ falsely identifying standing on occasion. This was often noted by the researcher if a child was sitting on a chair with their thighs hanging down towards the floor, thereby overestimating time in this monitor output category and lowering the predictive value. For walk, the overall *activ*PAL™ sensitivity of 80% was accompanied by a specificity of 96% and positive predictive value of 78%. As sensitivities are affected by the total time in the category, the percentages for those children (such as N0031) with only limited seconds in the walk category (less than 3 minutes of monitored time) may not be truly reflective of performance.

The validity of the *activ*PAL™ for ten children aged 5-17 years with cerebral palsy has been investigated by Tang et al (97). Although the authors state that this study investigates the validity in the free-living environment, validation against direct observation was undertaken only in the laboratory setting during the subject's routine gait analysis session. During this session, the subjects were asked to sit, stand and walk for periods of time and this was compared to videoed direct observation data. Then subjects were asked to wear the device for seven days in their free-living environment 'to determine their activity level in the free-living environment'. They report 'average accuracy' in detection for *activ*PAL™ category in comparison to video of 96.4% for sit/lie, 94.2% for stand and 92.1% for walking and 97.3% for step count. Interestingly they were also able to demonstrate differences between subjects on the basis of *activ*PAL™ output over seven days suggesting its use as a potential outcome measure or assessment tool in this population.

The most appropriate statistical summary measure for validation purposes is not straightforward and there is a wide range in terminology used in the literature. The overall sensitivity, specificity and positive predictive value (PPV) given for each monitor output category in the Results chapter of this thesis represent the sum of total correctly detected seconds in the category as a proportion of the total time spent in that category for data from all thirty children combined. It is therefore a measure of the agreement between direct observation and the *activ*PAL$^{TM}$ or DynaPort MicroMod. Alternatively, the median (with interquartile range) sensitivity, specificity and PPV for monitor output categories provided an impression of variation between individual children. If a monitor has perfect validation statistics in ten children and zero in two, the overall sensitivity may still look impressive but the monitor may be less useful if the degree of inaccuracy is substantial in a particular individuals. Alternatively, comparison of the proportion of time detected in each category may reduce any error introduced by time mis-synchronisation of the monitors for analysis but does not demonstrate whether these time periods were equivalent in terms of when they occurred.

The DynaPort MicroMod validation results in the present study were also encouraging however for the DynaPort output of 'sit' the overall sensitivity was 60.1% (with a specificity of 91.4% and PPV 84.9%). Similar to the *activ*PAL$^{TM}$, a range was seen across different children, which was greater than for the equivalent *activ*PAL$^{TM}$ data. Again taking account that sensitivity is affected by the total amount of time the child spent in the category (e.g. child N0008 has a sensitivity % of zero as none of the 66 seconds spent sitting were identified as such), several children spending a reasonable proportion of total observed time sitting were not classified accurately. Child N0012 spent 1672 seconds sitting yet only 379 of these were identified by the DynaPort as sitting. In comparison, child N00017 had 2287 seconds classified as sitting on direct observation of which 2267 were correctly identified as sitting and only 8 were identified as sitting when they were not (sensitivity 99.1%, positive predictive value 99.6%. Therefore for some children, the DynaPort was an excellent measure of sitting time but for others this was inaccurate. Further detailing in direct observation and analysis of the raw acceleration signals generated by those children with very good versus poor detection of sitting will help determine whether this reflects a requirement for a different posture detection threshold for sitting for young children or whether this is beyond the monitors capability.

For DynaPort MicroMod output 'stand' and 'walk' an overall sensitivity of 66.3%, specificity 71.2%, PPV 55.2%, and sensitivity 72.2%, specificity 96.1 % and PPV 77.6% respectively were found in the present study. The DynaPort output category of shuffle caused some difficulty with stand and walk validation as this was not a category for the direct observation data. Although referring to upright posture, this category represents a 'grey' unknown area where the software algorithm is not fulfilling criteria for either stand or walk. Although standing still and purposeful walking (or running) may be easy to identify, single steps or shuffles when e.g. playing at a sandpit or with toys are somewhat more challenging to identify. As seen by the frequent transitions between standing and waking according to the category transition tables, periods of walking were often brief and therefore when comparisons are made on a second by second by basis, any discrepancy in time matching or mis-synchronization of only a second could influence the results for stand and walk sensitivity, specificity and positive predictive values while affecting overall agreement with time spent in direct observation category to a lesser extent. We investigated the influence on validation results if seconds identified as shuffling were considered ('true positive') walking. This resulted in an overall improvement in sensitivity results at the expense of specificity and positive predictive value.

The DynaPort MoveMonitor algorithms have been recently validated in healthy adults and adults with chronic obstructive pulmonary disease (COPD) for the DynaPort MiniMod, a single unit system using the same accelerometry based technology as the MicroMod used in the study described in this thesis. In COPD, there is considerable interest in objective measures of assessing activities of daily living and activity as an outcome measure. Langer et al. described validation of posture and activity (including step count) in 10 healthy controls and 10 patients with COPD wearing the DynaPort MiniMod, DynaPort ADL monitor (the original DynaPort monitor including a waist worn unit and sensor on leg), and a SenseWear armband and comparing output with video analysis as the gold standard (74). The mean age for both groups was 65 years. Patients followed a set protocol (lasting 53 minutes) which the authors state were 'chosen to be representative of some everyday life tasks'. Inspection of this protocol however reveals that the order and duration of activity was prescribed and all behaviours were undertaken within the laboratory setting. To illustrate, their protocol consisted of asking subjects to lie for 4 minutes, sit 2 minutes, stand 1 minute, slow walk 6 minutes, sit 3 minutes, fast walk 4 minutes, sit 3 minutes, sweep 4 minutes etc. No comment is made regarding whether different sitting sections were on the same or different seating. Langer's posture validation results were impressive for both the DynaPort ADL monitor and the DynaPort MiniMod. Median (IQR) % agreement between direct observation and DynaPort MiniMod sitting time was 98.7% (91.6-99.6), 98.7% (93.3-99.2) for stand, 98.7% (95.9-99.5) for walk and 97.9% (97.1-98.7) for time spent lying (74). Interestingly, although excellent agreement was found between manual step count and the MiniMod, for one patient there was a large underestimation in steps. This patient was noted to walk slower than the other patients and this subject's data was excluded from their data analysis. Although walking speed was not measured as part of the study described in this thesis, it is possible that children's walking speeds may have resulted in some episodes of walking being captured by the DynaPort as shuffle or stand.

The DynaPort MicroMod results presented in this thesis may appear to compare poorly to the adult validation by Langer et al (74). However, similar to the adult *activ*PAL™ direct observation validation, the methodology was very different to that used in the present pre-school study. The level of agreement between direct observation and output in the DynaPort MiniMod adult validation study can not be assumed to be equivalent in the free living environment.

As stated previously, for both the *activ*PAL™ and DynaPort validation, seconds considered as 'other' according to direct observation (including crouch, kneel up, crawl and other) were both included and excluded in data analysis. From a practical perspective, because the total proportion of time in these postures was relatively small in contrast to the entire measurement period, little impact was seen on specificity or predictive values. The *activ*PAL™ tended to give a fairly standard output for postures such as crouch and kneel up (sit/lie and stand respectively). No obvious pattern was seen from the DynaPort output.

Any model system for postural detection that only has limited output categories needs to take account of the frequency and likelihood of 'unusual' or non-standard (non-sit/walk/lie/stand) transitions. By always saying a posture is something (rather than unknown), any non-standard postures will be misclassified if the monitor output categories are limited. The alternative is to have a detection system that is able to increase the number of categories in its output or have a distinct category for 'unknown' acceleration signals but this creates difficulties in analysis if relationships between postures are of interest.

Increasing the number of output categories is likely to reduce sensitivity for each detection category and furthermore distinction between e.g. *activ*PAL™ output for crouch and for sitting on a chair may not be technically feasible given the position of the monitor on the anterior thigh. However, such unavoidable classification may be acceptable. If a [crouch stand] transition is as important as a [sit stand] transition in terms of energy expenditure, the fact that the *activ*PAL™ does not differentiate them does not matter. The situation is less easy to justify when kneeling up or other more unusual postures are considered.

Apart from the *activ*PAL™ and DynaPort MiniMod and MicroMod monitors, few other single unit posture detecting activity monitors have been described in the literature to date (98;99). There are no published validation studies involving children for single unit systems in the peer-reviewed literature. Single unit monitors with an additional separate body worn data logging unit are considered in the multi unit sensor section below (100;101).

Mathie et al developed a framework for classifying activity and posture from a single waist worn accelerometer as a potential means of detecting falls in the unsupervised elderly (99). The single waist mounted tri-axial accelerometer (ADXL210, Analog Electronics) included a wireless transmitter and was 71 x 50 x 18 mm and weighed 50 g. Accelerometer output is initially classified into broad postural categories and then sub-categorisation of output provides additional detail. The authors acknowledge that the accuracy of categorisation falls as the number of subcategories increases, and also suggest that at any point in the signal detection algorithm there must be an opportunity to consider output as a separate unknown or other category. The algorithms were developed and tested on healthy adults (mean age 30.5 years) in a laboratory environment. Subjects performed timed (30 second duration) posture and activity according to a protocol in a pre-determined sequence (stand; lie supine; lie left side; lie face down; lie right side; stand; sit; stand; walk along a level corridor; stand; sit; stand; walk up a flight of stairs; walk down a flight of stairs; stand; sit; stand; walk along a level corridor; stand, and additionally simulated falls in 4 subjects). They found that an overall sensitivity across the algorithm of 97.7% and sensitivity for the detection of a sit stand posture transition of 93.5%. Some subjects data were used both for algorithm design and algorithm analysis and this may limit the interpretation of validity results. The system was then tested for practical utility in the free-living environment in six elderly persons aged 80-86 years (102). Subjects had a signal received and personal computer installed in their home for the duration of the study. Each morning participants followed a set list of tasks in their home including charging the battery and performing a known sequence of posture/activity in a ‘routine’ before continuing with normal daily activity. The study involved wearing the accelerometer every day for a period of two to three months. Compliance with study methodology was good with subjects wearing the device on 88% of intended measurement days (102).

Another single unit monitor under investigation is the Posture and Activity Detector (PAD) (98). This includes a tri-axial MEMS accelerometer and, similar to the DynaPort MicroMod, data are stored on a mini secure digital (miniSD) card. Bliley (98) reports that this monitor is being evaluated in a range of clinical applications including childhood obesity studies but does not discuss further details regarding this. If demonstrated to be a valid tool, the PAD is an attractive monitor because of its long battery life (over 14 days using a 10Hz data collection frequency) and a 128 MB miniSD card can hold up to a month of accelerometry data.

## 4.6 Measuring posture with multi sensor systems

The literature on multi-sensor accelerometer based systems for posture detection is more substantial. A balance exists between the acceptability and utility of activity monitors capable of capturing posture against the ability to accurately discriminate postures. Increasing the number and site of body sensors increases the ability to detect postural allocation accurately and increases the number of categories that can be identified. Several multi unit accelerometer based systems have been reported in the literature (61;66;70;74;100;101;103-115), often published with impressive validity statistics. A selection of these (including all with published validation in childhood) are discussed here.

The Activity Monitor described by Bussmann et al (70) involves four accelerometers (worn on the lateral surfaces of the thigh, trunk and lower arms) and a waist worn data logger (weight of data logger 700g). This is capable of detecting more than twenty different postures. In addition, if signal interpretation does not conform to their algorithms, an ‘unknown’ category applies. The Activity Monitor has been validated in a number of studies in both healthy and disease specific populations (106-108;112;114), including test re-test reliability (116). Its validity in adult patients (n=10) following failed back surgery and with chronic pain was tested in subjects performing usual activities (selected from a list of possible activities which included making a bed, vacuuming, using a dustpan and brush) in their own home with videoed direct observation as the gold standard (107). Of note, in this paper the authors commented that squatting (crouching) was coded as standing by the direct observation (as the seat was not supported by the feet or lower legs), but as sitting by the Activity Monitor. They reported an overall agreement between the Activity Monitor and direct observation of 87% (inter subject range 83-88%). When they re-classified squatting time instead as direct observation sit, there was only a modest effect on overall agreement (88%) but the number of sit stand posture transitions was more accurately assessed. The Activity Monitor has also been validated in ten adult patients with heart failure in their own homes using direct observation as the gold standard (112). Overall agreement between the Activity Monitor and direct observation was 90% for posture detection (range 82-97% between subjects) and the total number of posture transitions detected by direct observation and the Activity Monitor was not statistically different.

The DynaPort ADL monitor has been validated in healthy adults and adults with chronic obstructive airways disease (74;111;117). It consists of a single unit sensor and data logger worn in a neoprene belt around the waist and a leg sensor. The total weight of the system is 375g. It has been shown to have excellent agreement with direct observation in adults (74). It has also been validated in free-living school children and this is discussed in more detail below.

The Intelligent Device for Energy Expenditure and Activity (IDEEA) (MiniSun, California, US) can potentially measure duration, frequency, and intensity of various types of physical activity. The IDEEA has been validated for its output of five primary postures (sitting, standing, leaning and lying) and 22 sub-postures (115). The IDEEA consists of five small biaxial accelerometer sensors (16 x 14 x 4mm) which are attached by wires to a data collector box worn on the waist. The sensors are worn on the chest, both thighs and on the soles of the feet. The system weighs 200 grams. Validation in a laboratory setting gave average identification rates for posture of 98.9% in a study of 68 subjects aged 13-72 years. Sitting posture is sub-classified as upright (normal), left leg over right, right leg over left, elbows on legs, left foot under seat, right foot under seat, both feet under seat, or feet elevated. Stand is sub-classified as pick up object, left foot up, upright (normal) and right foot up. Validation was undertaken by the subjects copying a posture adopted by a researcher, and holding this for ten seconds (two researchers recorded the postures) and the final five seconds in each posture were used for comparison analysis. The authors acknowledge that wires connecting the sensors may be inconvenient, but in the future wireless technology may enable a more practical device.

Paraschiv-Ionescu et al have validated two methods to measure posture (and gait using a gyroscope on the lower leg) (101). The first posture detection method involved two accelerometers (chest and thigh) and a waist worn data logger and the second system tested involved a single accelerometer (thigh only) connected by wire to a waist worn data logger as before. Validation was carried out in 21 adult patients with chronic back pain. The authors state that ‘the patients performed different activities at their own usual pace, indoor as well as outdoor’ but data collection took place within the hospital setting. Direct observation was used as the criterion measure and posture (walking, lying, sitting and standing) including each postural transition was recorded. Comparison was also made with the method proposed by Najafi (a system which involved one chest worn monitor consisting of a gyroscope and two accelerometers connected by wire to a waist worn data logger)(100). Paraschiv-Ionescu reported a sensitivity of 98.2% for sitting with the thigh accelerometer alone, 97.8% with two accelerometer system and 86.9% for the original method reported by Najafi. The authors also acknowledged that neither of their two proposed posture detection methods could differentiate sit from squatting (referred to in this thesis as crouching) however they suggest that this would not introduce significant error as time spent in such postures is likely to be limited.

In the validation study described by Najafi et al (100), eleven elderly persons wore retroreflective markers (Vicon™, Oxford Metrics, U.K.) on their trunk and were filmed participating in a series of tests designed to involve different postures. This study is of note because it specifies that sitting postures were validated using a range of different chairs (including an arm chair and a wooden chair). They then described nine subjects wearing the system whilst participating in their usual activities. During this time an observer recorded the activity undertaken (including posture and postural transitions). In this activity of daily living section, reported sensitivity and specificity for sit were 90.2% and 93.4% respectively, 'standing and walking' 92.2% and 92.2% and lying 98.4 and 99.7%(100). However, the wavelet analysis system used for signal interpretation meant that a period of stability was required (4 seconds) for the sensors to categorise posture following a transition. This even included walking immediately after a transition, thus limiting its utility in a population where frequent transitions may be more common.

Lyons (110) has reported the evaluation of an accelerometer based posture detection system based on two sensors in the free-living environment of an elderly person (n=1) who had recently had a stroke in a rehabilitation centre for a period of over 29 hours. Direct observation data was recorded in real time on a minute by minute basis (it was considered that more frequent data recording and filming were necessary and inappropriate due to the patient and environment).

Several different multi-unit accelerometer based posture detection systems have been validated in child populations. In children, sitting standing and lying postures were identified using a combination of accelerometers and inclinometers fixed on to Lycra® shorts and top by Lanningham-Foster et al (66). This has been called the Physical Activity Measuring System (PAMS). The original PAMS included four inclinometers (positioned over the lateral aspects of both lower thighs and on the left and right at the waist) and two accelerometers (worn at the lower back), combined weight 1.2 kg. In view of this weight burden, the PAMS modified for use in children includes two inclinometers (over the mid thigh) and one accelerometer to measure activity intensity, weight 700g. With the first set up, body position was correctly identified in all 2880 measurements performed in eight children (mean age 9.1 years) as either lying, sitting standing or walking (66). The Lanningham-Foster et al validation protocol was undertaken with strictly controlled 'laboratory' conditions (66). Sitting and standing time were undertaken for periods of ten minutes each. Standing was performed on a standing mat with children directed to stand still after placing each foot over an outline of the corresponding foot on the mat. The modified

PAMS system, tested with the same protocol correctly identified body posture in 5575 out of 5575 measurements (66).

The DynaPort ADL Monitor has been validated in school children for its ability to identify lying, sitting, standing, walking (including walking, running crawling and cycling) and going on a swing or seesaw (105). This unit is bulky, consisting of accelerometers and a digital recorder worn in a backpack and a further sensor worn on the right upper leg in a neoprene strap. The combined system weight was 295g. Methodology however was similar to the study described in this thesis. Validation was performed in the free-living school environment with direct observation as the gold standard, without any stipulation about activity undertaken whilst wearing the monitor. The authors reported 'minimal and maximal validity percentages', with minimal validity defined as the agreement of the monitor and video observer at the same time and maximal validity as agreement across the measurement. The overall minimal and maximal validity were 73.15% (SD 4.48) and 91.31% (SD 1.75). Similar to findings in this thesis, Busser (105) acknowledged the challenge of categorising all 'normal' child activity into one of the DynaPort ADL monitor output categories.

There is only limited information about the use and validity of the IDEEA for posture detection in child populations. Mackey et al validated the IDEEA in children and adults with cerebral palsy (aged 8 years and over) to assess temporal-spatial gait parameters but not posture (118). Following this, Mackey et al have recently published a validation study of the IDEEA in 25 young people with cerebral palsy and 30 able bodied persons, age range 8 – 25 years, for posture detection capability (119). Validation was carried out in the gait laboratory, with participants carrying out a protocol of postures (sitting, standing and lying) for 30 seconds duration, walking up stairs and walking on a level surface. Comparison between observation and IDEEA output was made for seconds 11-30 in each posture. The authors reported a median sensitivity of 100% for detection of sitting, lying and standing in both groups. They also reported that their younger study participants objected to the wires of the device and therefore refused to wear the IDEEA device for extended periods of time.

The studies validating different multi unit sensors for posture detection described above demonstrate that the body of literature is far more substantial for multi-unit than single unit sensors. However, the author of the present study opted to validate single unit monitors because of the likely potential limitations of multi unit sensors in presenting practical problems and acceptance in free-living young children (66;119).

## 4.7 Validation environment: Free living vs. laboratory

It is important that validation of any system for detecting movement and posture is undertaken both in the population of interest and in an environment in which that population inhabits. The vast majority of validation of posture measurement systems to date has been undertaken in laboratory type environments and activities with limited data available for validation in the free-living environment. For example, literature searches for the present thesis failed to find any free-living validation of the PAMS developed by Levine’s group (66) and yet these have been used in free-living studies to investigate differences in posture allocation between obese and non-obese adults (61).

A similar break in the chain of validation between laboratory and free-living application is seen in methods to detect step count and walking with only very few monitoring systems (for example the Step Watch™ and *activ*PAL™ detected step count (120)) tested outside the laboratory environment. It is likely that the differences between laboratory and field validation would be greatest for single unit instruments, like those used in this study. It is also questionable whether validation in artificially staged environments designed to test activities of daily living is equivalent to the free-living environment with the same degree of accuracy, particularly for single unit monitors, and especially for studies of young children.

The range of postures and unusual ways that children manoeuvred around their environment in the present study illustrated the importance of making efforts to test any monitors aiming to capture postural information in an environment in which the population of interest inhabits. We did not design our study in a laboratory or artificial environment, e.g. setting a room up with a particular chair and table at which to sit, or route to walk around. Although this may be considered an appropriate first stage validation approach, the author suggests that such results could not be readily translated to the free-living (usual) child environment. However, testing a monitor in a challenging way both in terms of population and environment then means that validity in other situations (e.g. older children) is likely to be between that of the current study and the published adult validation studies.

As described previously, validation of monitors capable of detecting posture tends to compare direct observation with monitor output categories with no grey area or 'unknown' category. No literature exists on the deliberate assessment of 'non-standard' postures. It is not clear from the literature how 'other' categories were dealt with or defined during monitor validation for monitors with outputs of only a few categories such as those of the *activ*PAL$^{TM}$ or DynaPort. It is possible that this reflects both the population and the environment in which they have been validated. It is likely that adults do not crouch or kneel up as much as young children. Therefore, this is probably less of a concern for adult validation studies.

An alternative approach to validation against direct observation in the free-living environment has been to compare a novel system with a previously validated objective posture detection method. Both the *activ*PAL$^{TM}$ and the DynaPort MiniMod have been validated in this way in adults. The *activ*PAL$^{TM}$ has been validated against an activity monitor comprising of two Analog Devices ADXL202 accelerometers (one attached to the sternum, one to the same thigh as the *activ*PAL$^{TM}$) attached to a data logger (the Activity Monitor configuration)(70). Subjects were free to move around a university campus during the data collection period (six hours). Comparing 60 hours of data from ten healthy adult subjects, the author's found an overall difference of only 0.06% minutes between the *activ*PAL$^{TM}$ and comparison accelerometers for the output of 'sit', 0.5% for standing and 1.64% for stepping (71). The overall accuracy of the *activ*PAL$^{TM}$ in comparison to the two discrete accelerometers was 98% (71).

This approach to validation in the free-living environment has also been recently employed for the DynaPort MoveMonitor algorithms (121). Instead of comparison against direct observation, the monitor is compared with an already validated posture and activity detection system. Whereas the *activ*PAL$^{TM}$ was compared against the ADXL202 accelerometer output as described above, the DynaPort MoveMonitor algorithms (using a MiniMod) has been validated against the DynaPort ADL-Monitor alone (121). The DynaPort MoveMonitor algorithms (using a single MiniMod monitor worn at the lower back in a neoprene belt) were compared with DynaPort-ADL output over a 24 hour period of free-living activity in 18 adults across a range of ages. Van Lummel et al (121) compared % agreement, sensitivity, specificity and error in measurement between the two monitors for outputs of sit, lie, stand and walk. They found that overall agreement for lying was 99%, sitting 89%, standing 63%, and locomotion 84%. However, variation was seen across different age groups of study participants, with the highest agreement for sitting in the oldest age group (95% in those aged >80 years (n=4) vs. 80% in adults aged 30-60 years n=4)). Conversely, standing and walking agreement was lowest in oldest age group (53% and 69% respectively). Overall sensitivities/specificities were 99.3%/97.0% for lie, 88.8%/91.6% for sit, 63.5%/96.5% for stand, and 84.5%/99.7% for walk. Of note, the standard deviation reported for sit sensitivity was 9.2%, stand 9.9% and walk 14.5% suggesting that there was a variation in these measures between individual study participants. In addition, although agreement and sensitivity was quoted separately, the definition of agreement was 'total duration that the ADL-Monitor and the MoveMonitor corresponded at the same moment for all categories/total duration that the activities were classified by the ADL-Monitor x 100%', suggesting in fact that this was equivalent to sensitivity (and thus perhaps explaining why the quoted results are the same).

This method of comparing a new monitor to existing validated systems is of interest because of its potential application to the free-living system. It also negates the potential intrusiveness of direct observation in the home environment. However, weight and bulkiness of the comparison system may limit its use for validation studies in the free living pre-school child. In addition, by comparing only against the same output categories, the potential for both monitors to simultaneously capture but misidentify a movement or posture such as kneel up would occur but not be able to be differentiated.

Busser et al (105) investigated the influence of environment on validation as a n=1 substudy of the child DynaPort ADL monitor validation described above (105). They undertook validation against direct observation both during school lessons and during 'intensive play'. They reported that under 'normal' conditions the validity was between 97-99%, but during play activity between 50-92%.

Even if validation has been undertaken in a free-living setting, validation in healthy adults does not necessarily translate to other populations. Several studies have been undertaken to validate monitors in a disease specific or age specific population of interest. However, again the environment chosen for validation may not be optimal. Harris et al. investigated the validation of the PAMS system developed by Levine in eight female adults with anorexia nervosa and eight female healthy controls (122). Similar to the laboratory based methodology used in the original PAMS validation, the women were asked to lie, sit, stand motionless and walk at a series of pre-determined speeds whilst wearing the body worn sensors. The authors of this study commented perhaps not surprisingly that 'PAMS showed remarkable sensitivity and specificity with respect to detecting posture. In all participants the PAMS data correctly distinguished lying from sitting (300/300) and sitting from standing (300/300 cases)'.

## 4.8 Conducting physical activity research in the nursery setting

In the validation study described in this thesis, the *activ*PAL™ and DynaPort were assessed on pre-school children in their own nursery environment undertaking usual nursery activity. However, pre-school children do not spend all their awake hours at nursery. Their home environment may be different in terms of size of furniture, type of toys or outdoor play equipment such as a swing. Yet, a range of activity between children throughout the measurement time, including indoor and outdoor play was seen in the present study. This variation in activities has been considered useful in previous accelerometry validations in nursery settings (51). Interestingly, the overall average proportion of time spent sedentary in the sample of children in the present study was similar to larger studies in the free living environment (32). In addition, evidence suggests that in young children, moderate and vigorous intensity physical activity contribute little to free-living behaviour and free-living total energy expenditure (33), and therefore an environment which may favour sedentary behaviour is appropriate for validation.

The nurseries provided a useful environmental setting for data collection in the present study, and results may be relevant to the wider free living environment which pre-school children inhabit. No direction was given to children about what activity should be undertaken during their observation period, and the researcher did not ask the children to perform any particular posture or activity routines.

Because no interference with usual nursery timetabling was requested during data collection, all activities (including any mealtimes) falling within the direct observation period were included. Similarly, children with data collection including outdoor free play occurred when this formed a planned part of the nursery day. Therefore, this study does not (nor intended to) represent pure free-play or comment on comparisons in activity between different children. Instead, the filming of children either on their own or in child pairs meant that across the entire study a wide range of type and pattern of activity were represented. This was considered particularly important for sitting, where heterogeneous positions were observed. Including all ways in which children negotiated and utilised their nursery environment was likely 'truer' than a prescribed routine of e.g. sitting on a specified chair for set periods of time. Sitting during mealtimes, structured lessons, free play, on a chair or on the floor, and on a variety of pieces of play equipment meant that validation of 'sit' was likely more representative of free-living sitting behaviours.

The nursery environment was not appropriate to validate the 'lie' output for either monitor in the present study. A similar outcome was found for the DynaPort ADL monitor validation study in children (aged 4-10 years) undertaken in their free living school environment by Busser et al (105). Busser found that the nine children studied spent only 2% of total measured time lying down (and it was not clear whether this time was from one child's data or shorter periods from different children)(105). In the study described in this thesis, only fifteen children lay down for any part of their monitoring time and for ten of these the duration for direct observation lie was less than 30 seconds for that child's total measurement period. Therefore the lie output category can not be properly evaluated using the methodology (in terms of environment) of this study. Similarly, monitor output whilst in a car or on a bus needs further investigation. In addition, the childhood validation of the original DynaPort ADL monitor included a monitor output category for swing and see-saw due to difficulties in accelerometer signal interpretation. No swings or see saws were in any of the 3 nurseries used in this study and therefore this was not investigated.

## 4.9 Practical utility of posture measurement systems

The present study was not intended to assess the practical utility of the two monitors tested in pre-school children. Wearing an ActiGraph, *activ*PAL™ and DynaPort MicroMod in its neoprene belt and being videoed at the same time created a novelty interest among the children. Because the study involved children wearing all three monitors, the utility of each monitor individually could not be assessed. It is not known whether the children that did not want to wear the monitors for the entire measurement period or those managing to pull the *activ*PAL™ off their leg through being inquisitive would have done this if they were only wearing one monitoring or if there was no videoing.

There was no evidence to suggest that children had any limitation to free-living activity by wearing all three monitors at the same time. Therefore, wearing only either the *activ*PAL™ or the DynaPort MicroMod is unlikely to limit free-living usual physical activity.

Practical utility of both the *activ*PAL™ and DynaPort MicroMod are being assessed in ongoing separate studies that will involve free-living pre-school children wearing either the *activ*PAL™ or DynaPort MicroMod for a period of several days.

## 4.10 Considerations for future validation studies

In addition to the challenges faced through the environment, characteristics of monitors systems and direct observation comparison methods, several other areas of methodology adopted in the study described here deserve discussion.

### 4.10.1 Limitations with single hand held video camera

In the study presented in this thesis, direct observation data were captured by a single researcher with a hand-held video camera. This approach meant that, by the nature of the nursery environment and that children's activity was not directed, there were frequent (usually very brief) periods when the child wearing the monitors was either obscured or off screen. For comparisons between time matched seconds, this did not create any problems as comparisons between direct observation category and monitor output were made on the basis of on screen seconds only. However, posture transitions were affected, as potential real posture transitions could have occurred when the child was off screen. Therefore, comparisons between postures detected on direct observation and by either the *activ*PAL™ or the DynaPort MicroMod were made only during the longest uninterrupted section of filming per child. Because for some children the frequency of transition was low there were no transitions in the longest uninterrupted segment (however, falsely detected monitor transitions could still be assessed). It was also not always feasible nor appropriate to follow the child at all times during the filmed period, for example when they went in to the toilets, ran behind trees or playing inside a Wendy (toy) house etc. It potentially could have been possible for the researcher to follow the children inside the Wendy house or behind trees but aside from possible practical size issues, it would have likely interfered with the child's play and increased awareness of them being observed. Video observation with multiple sited cameras may in part address these problems although this would require additional resources.

### 4.10.2 Direct observation data analysis

As described previously, direct observation data was analysed by the author (i.e. single researcher) with description of posture and activity on a second by second basis. Analysis of videoed direct observation data when validating activity monitors has been similarly performed by a single observer in other studies reported in the literature (74;105;123). This includes the validation of the original DynaPort ADL monitor described above in adults and children (105;123). More recently, a single investigator analysed the direct observation data validating the DynaPort MiniMod in adults (74). In addition, the ActiGraph accelerometer cut-offs for sedentary behaviours in pre-school children were defined with a single observer in the child's nursery categorising activity according to the Children's Physical Activity Form (51).

In the study described in this thesis, posture and activity were described per second, and if multiple transitions occurred within a single second, all were recorded. There was therefore no requirement to allocate only one activity intensity to a specified time period, as could arise with classification systems summarising activity over e.g. 10 second samples. Interobserver agreement has not been formally investigated within this study however, in view of the above, it would not be anticipated that there would be significant discrepancy. The interobserver agreement between researchers analysing the video of the Activities of Daily Living section of the adult *activ*PAL™ validation study by Grant et al found that this was >0.97 for all postures (sitting, standing and walking)(73).

### *4.10.3 Multiple transitions within single seconds*

Because of the potential importance of being able to quantify postural transitions in addition to total time spent in posture categories, it is important to assess the ability of monitors to capture each true posture transition that occurs. Similarly it is important that each posture is captured by direct observation techniques. In the study described in this thesis, any second with more than one posture transition occurring within it was counted as having an equivalent additional 'second' for comparison. This meant that all transitions were counted regardless of duration. An exception to this was with the frequent single seconds with a transition to both stand and shuffle from the DynaPort MoveMonitor output, which were not awarded additional 'second' status. Any seconds with two transitions therefore resulted in an artificial second in the comparison output, thus generating potential error. However, the overall proportion of seconds that were influenced in this way was small and it was considered that the inclusion of all transitions was more important to include than the potential error created by the very small addition of comparison 'artificial' seconds. There is no evidence in the literature to suggest how other researchers have dealt with this problem. It is possible that the use of a one second (rather than the ten second default) minimum sitting time increased the number of seconds with two transitions for the *activ*PAL™ data in the present study, however this was considered necessary to ensure that even brief transitions could be captured by the monitor. This methodology is in comparison to validation of certain posture detecting monitors in the literature where postures with a duration of less than e.g. five seconds were not considered in data analysis(112;116). In pre-school children, postures such as crouching down (e.g. to pick up a toy) are common and these may be very brief in duration. It is therefore important that any system for application in this population can not only accurately detect sustained postures but also capture very brief episodes of postural change.

### *4.10.4 Detection of postural transitions*

The method of posture transition detection used in the present pre-school validation study involved identification of the relationship between consecutive seconds in either direct observation or *activ*PAL™/DynaPort output. This enabled comparison between total sedentary times and various posture transitions for all on screen direct observation data. The method of using this same approach (i.e. relationship between seconds) for the longest uninterrupted period per child to compare transitions on direct observation against those detected by either monitor provided an overall number of each type of transition during this period. However, it did not allow assessment of whether the transitions captured represented the same activity or were independent of each other. For example, using this methodology four sit-stand transitions on direct observation and 4 sit-stand transitions detected by the *activ*PAL™ did not give any information about whether this refers to the same (true) transitions or not. Therefore what is presented in this thesis is an assessment of the *overall* agreement between direct observation and monitor output rather than the sensitivity and specificity of ‘real time’ postural detection.

## 4.11 Posture as an outcome measure

Several studies have been published which include objective measures of postural allocation and transition in the free-living environment. Levine used their PAMS system involving inclinometers tri-axial accelerometers (89;124), to record body position and motion in obesity research (61). As discussed in the

Introduction chapter, ten healthy and ten ‘mildly obese’ adults (BMI 33±2 $kg/m^2$) wore this system for a period of 10 days to look at differences between groups, and the effect of subsequent diet or overfeeding on posture allocation. The study participants were asked to continue their usual daily activities during this time. Results analysis involved looking at the differences between time spent in different postures between lean and obese subjects. More recently this group have used the same PAMS set up to investigate whether free-living daily walking distance is lower in obese than lean subjects (125). Although walking was the primary outcome of interest, they also analysed accelerometry output for the postures lie, sit, stand and walking in ten lean (BMI ≤25 $kg/m^2$) and 12 obese (BMI ≥29 $kg/m^2$) adults. The PAMS system has also been used to assess non-exercise movement in the elderly (126), to investigate any reduction in non-exercise movement objectively in comparison to younger adults. Ten lean elderly subjects wore the PAMS for 10 days and comparisons were made with 10 younger adults. Posture outcomes for each subject were calculated as the average daily number of minutes spent in PAMS detected lying, sitting and standing/ambulating categories. Although the actual days of measurement were free-living, participants had their PAMS systems tested in the laboratory on each day of data capture to check validity, with sensors removed by researchers. No errors in detection were found (126) but such a protocol would limit the practical utility of any posture detection system in the longer term.

Several studies have been published using the original DynaPort activity monitor (leg and waist sensor) as an outcome measure in cross sectional studies (123;127-129). This DynaPort activity monitor has been used particularly in patients with chronic obstructive airways disease (COPD)(123;127;128). For example, Pitta et al investigated differences in sitting, standing and time between elderly persons with (n=50) and without (n=25) COPD as detected by the DynaPort activity monitor (123). Interestingly, they also undertook a substudy to determine the number of assessment days that the DynaPort should be worn. In this substudy, five consecutive days of data recordings were collected and results analysed to determine the number of days to achieve a between-day intraclass reliability coefficient of ≥ 0.7 according to the methodology of Trost et al (130). They concluded that two days of measurement were sufficient.

The Activity Monitor described by Bussmann(70) has been used to assess differences in the level of activities of daily living between subjects with mild congestive heart failure (n=5) and age matched controls (n=5)(131). Three days of data collection (two days for controls) with subjects wearing the Activity Monitor were undertaken and comparisons made in the proportion of time spent in active and inactive monitor output categories between groups. A similar duration of data collection using the Activity Monitor has also been undertaken in adolescents and young adults (age 14 to 26 years) with the neural tube defect meningomyelocele in comparison to controls (132), and in the same patient group for a comparison in time spent in dynamic activities against healthy controls (133).

The *activ*PAL™ posture detection output has been used as an outcome measure in a number of studies across a variety of fields. In physical activity research, it has been used as an instrument to measure whether a sample of 114 Glasgow postal workers (both delivery workers and office based) complied with physical activity guidelines(134). The *activ*PAL™ has been used in a study to investigate mobility in patients with venous leg ulceration(135), with comparisons between patients and controls in the number if steps and amount of time spent walking, standing sitting or lying over a seven day measurement period. The *activ*PAL™ has also been used to measure upright and active time in patients with chronic low back pain against the degree of psychological distress experienced (136) and as a way of defining subtypes of delirium according to activity parameters (137-139). Other field based applications using the *activ*PAL™ have been summarised by Godfrey et al (46). These include activity patterns in the elderly, functional assessment of amputees, and measurement of physical activity in determining cardiovascular risk, with results of these studies at present published only as conference proceedings and not yet in the peer-reviewed literature.

The results presented in this thesis suggest that the two monitors evaluated, particularly the *activ*PAL™, could be a useful outcome measure in future studies involving young children, contingent on evidence that practical utility is acceptable in free-living conditions.

What is acceptable in terms of validation statistics for posture detection systems has not been well defined in the literature. Busser suggested that a validity of

73% was acceptable in free-living children (105). Comparison can also be made with the ActiGraph pre-school validation study by Reilly et al (51) that demonstrated 83% sensitivity and 82% specificity in detecting sedentary behaviours according to defined cut points which have since been widely accepted and used. The lower sensitivity for DynaPort MicroMod sit found in the present study means that this device may not currently be ideal for posture measurement in young children, and it depends how much this is as a result of algorithms for signal analysis that could be modified to improve detection and how much of this is because a lack of being able to discriminate sit or stand postures (in particular) due to site of monitor placement. The present study suggests that the *activ*PAL™ may be better suited to outcome measures involving total time sitting etc. rather than as an outcome measure which also includes number of transitions, given that these were overestimated in comparison to direct observation.

The future is likely to bring new developments in terms of monitor development and refinement of algorithms for posture detection. New technologies offer the potential for multiunit systems going ‘wireless’ and smaller, thus increasing the potential for accelerometry based posture detection systems which could be practical as a tool for objective measurement in pre-school children. In addition to the field of physical activity research and obesity, other potential applications include rehabilitation from musculoskeletal morbidity or longitudinal assessment of functional ability in children with chronic disease.

## 4.12 Conclusions

The validation studies described in this thesis suggest that postural information can be collected using single unit accelerometry monitors in pre-school children. The acceptable accuracy of systems and perceived benefits over non-posture defining existing methods will impact on their use as measurement tools in the wider field on objective measures of physical activity. The performance of both the *activ*PAL™ and DynaPort MicroMod monitors against the gold standard of direct observation was slightly inferior to that in adult validation studies (73;74). However differences, in terms of study methodology, population and environment existed which might mean that such differences might have been expected, in particular the likely difference between validation studies in laboratory versus free living conditions.

To improve the validation against direct observation, recorded data categories need to be wider than the categories of output for a monitor under test, particularly if limited to sit/lie, standing and walking/shuffling. We should therefore perhaps learn from the ergonomics field and record in more detail than the standard limited output categories in small single unit monitors that are likely to be most useful in terms of practical utility particularly in pre-school children. Optimising this will then help the evaluation, using direct measures of energy expenditure, of the importance of posture allocation and posture transition including the energy cost of 'normal' sit stand transitions and other non-standard transitions in children. The potential usefulness of further work in this area goes beyond the field of childhood obesity. The direct observation data presented in this thesis have illustrated the potential importance of measuring postural transitions and not just time spent sedentary. If objective measures could enable accurate capture and agreed classification of posture and posture transitions, the opportunity to investigate free-living child behaviour beyond current capabilities will exist. This should include defining normal ranges for number of posture transitions over specified periods of time across different child ages and in different environments, and an investigation into how this may vary between groups (e.g. non-obese vs. obese children).

Finally, that we can measure something does not mean that we understand what we are measuring nor mean that we should measure it. Continued effort to strive for best practice methods in validation, particularly in the free-living environment is important. However, there is a need to be confident that what we are measuring is both what we intended to measure in the first place and is useful to measure, i.e. it can be interpreted in terms of equating with outcome or risk. Future studies of posture measurement systems in young children should also consider these more fundamental questions.

# 5 Appendices

## 5.1 Monitors

| Monitor | Monitor serial numbers | |
|---|---|---|
| | Set A | Set B |
| *activ*PAL™ | AP060741 | AP060762 |
| DynaPort MicroMod | MV6015 | MV6016 |
| ActiGraph GT1M | LYN1B52050039. RENATA ICP603028, 5150592004 | LYN1B52050043. RENATA ICP603028-S, 515050920045 |

Set A and B refer to arbitrary identification labels applied to the monitors to identify standard 'sets' for data collection. The monitor sets worn by each child are shown below, in addition to whether data collection occurred for one child alone or child pairs.

| Child | Monitor set (A or B) | Data collection on own (O) or in pair (P)? |
|---|---|---|
| N0001 | A | P (with N0002) |
| N0002 | B | P |
| N0003 | A | P (with N0004) |
| N0004 | B | P |
| N0005 | A | P (with N0006) |
| N0006 | B | P |
| N0007 | A | P (with N0008) |
| N0008 | B | P |
| N0009 | A | P (with N0010 then N0011) |
| N0010 | B | P |
| N0011 | B | O then P with N0009 |
| N0012 | A | P (with N0013) |
| N0013 | B | P |
| N0014 | A | O |
| N0015 | A | P (with N0016) |
| N0016 | B | P |
| N0017 | A | O |
| N0018 | A | P (with N0019) |
| N0019 | B | P |
| N0020 | A | O |
| N0021 | B | P |
| N0022 | A | P (with N0023) |
| N0023 | B | P |
| N0024 | A | O |
| N0025 | A | P (with N0026) |
| N0026 | B | P |
| N0027 | A | P (with N0028) |
| N0028 | B | P |
| N0029 | B | P |
| N0030 | A | O |
| N0031 | B | O |
| N0032 | A | O |

## 5.2 Example data from *activ*PAL™, child N0001

| time | activity | duration (s) | steps | cumulative steps |
|---|---|---|---|---|
| #2008-10-02 09:37:20# | stand | 62.6 | 0 | 110 |
| #2008-10-02 09:38:22# | walk | 4.1 | 4 | 114 |
| #2008-10-02 09:38:26# | stand | 103.1 | 0 | 114 |
| #2008-10-02 09:40:10# | walk | 1.1 | 2 | 116 |
| #2008-10-02 09:40:11# | stand | 78.2 | 0 | 116 |
| #2008-10-02 09:41:29# | sit/lie | 1.6 | 0 | 116 |
| #2008-10-02 09:41:30# | stand | 35.3 | 0 | 116 |
| #2008-10-02 09:42:06# | walk | 2 | 2 | 118 |
| #2008-10-02 09:42:08# | stand | 1.5 | 0 | 118 |
| #2008-10-02 09:42:09# | sit/lie | 18.9 | 0 | 118 |
| #2008-10-02 09:42:28# | stand | 8.8 | 0 | 118 |
| #2008-10-02 09:42:37# | sit/lie | 4.4 | 0 | 118 |
| #2008-10-02 09:42:41# | stand | 15.1 | 0 | 118 |
| #2008-10-02 09:42:56# | sit/lie | 13.5 | 0 | 118 |
| #2008-10-02 09:43:10# | stand | 9.2 | 0 | 118 |
| #2008-10-02 09:43:19# | walk | 7.8 | 4 | 122 |
| #2008-10-02 09:43:27# | stand | 3.5 | 0 | 122 |
| #2008-10-02 09:43:30# | sit/lie | 32.7 | 0 | 122 |
| #2008-10-02 09:44:03# | stand | 3.8 | 0 | 122 |
| #2008-10-02 09:44:07# | walk | 6.7 | 12 | 134 |
| #2008-10-02 09:44:14# | stand | 16.2 | 0 | 134 |
| #2008-10-02 09:44:30# | walk | 5.9 | 6 | 140 |
| #2008-10-02 09:44:36# | stand | 8.8 | 0 | 140 |
| #2008-10-02 09:44:45# | walk | 20 | 24 | 164 |
| #2008-10-02 09:45:04# | stand | 11.7 | 0 | 164 |
| #2008-10-02 09:45:16# | walk | 31.3 | 32 | 196 |
| #2008-10-02 09:45:47# | stand | 6.8 | 0 | 196 |
| #2008-10-02 09:45:54# | sit/lie | 1.1 | 0 | 196 |
| #2008-10-02 09:45:55# | stand | 8.1 | 0 | 196 |
| #2008-10-02 09:46:03# | walk | 6.1 | 4 | 200 |
| #2008-10-02 09:46:10# | stand | 28.3 | 0 | 200 |
| #2008-10-02 09:46:38# | walk | 12.6 | 14 | 214 |
| #2008-10-02 09:46:51# | stand | 33.3 | 0 | 214 |
| #2008-10-02 09:47:24# | walk | 5.5 | 8 | 222 |
| #2008-10-02 09:47:29# | stand | 9.5 | 0 | 222 |
| #2008-10-02 09:47:39# | sit/lie | 3.8 | 0 | 222 |
| #2008-10-02 09:47:43# | stand | 12.4 | 0 | 222 |
| #2008-10-02 09:47:55# | sit/lie | 1.4 | 0 | 222 |
| #2008-10-02 09:47:56# | stand | 5.6 | 0 | 222 |
| #2008-10-02 09:48:02# | sit/lie | 6.7 | 0 | 222 |
| #2008-10-02 09:48:09# | stand | 5.5 | 0 | 222 |
| #2008-10-02 09:48:14# | sit/lie | 1.9 | 0 | 222 |
| #2008-10-02 09:48:16# | stand | 16.8 | 0 | 222 |
| #2008-10-02 09:48:33# | walk | 1.7 | 2 | 224 |
| #2008-10-02 09:48:35# | stand | 17.9 | 0 | 224 |

# 5.3 Example data from DynaPort MoveMonitor, child N0001

| ID | Start time | End time | Classification | Amount of Steps | Movement Intensity |
|---|---|---|---|---|---|
| 1 | 0:00:00 | 0:00:37 | Standing | 0 | 0.345 |
| 2 | 0:00:37 | 0:00:39 | Shuffling | 0 | 0.348 |
| 3 | 0:00:39 | 0:00:39 | Standing | 0 | 0.243 |
| 4 | 0:00:39 | 0:00:40 | Shuffling | 0 | 0.349 |
| 5 | 0:00:40 | 0:00:45 | Standing | 0 | 0.381 |
| 6 | 0:00:45 | 0:00:45 | Shuffling | 0 | 0.056 |
| 7 | 0:00:45 | 0:00:49 | Standing | 0 | 0.059 |
| 8 | 0:00:49 | 0:00:51 | Shuffling | 0 | 0.073 |
| 9 | 0:00:51 | 0:00:51 | Standing | 0 | 0.069 |
| 10 | 0:00:51 | 0:00:52 | Shuffling | 0 | 0.076 |
| 11 | 0:00:52 | 0:00:53 | Standing | 0 | 0.038 |
| 12 | 0:00:53 | 0:00:55 | Shuffling | 0 | 0.066 |
| 13 | 0:00:55 | 0:01:19 | Standing | 0 | 0.040 |
| 14 | 0:01:19 | 0:01:22 | Shuffling | 0 | 0.097 |
| 15 | 0:01:22 | 0:05:05 | Sitting | 0 | 0.036 |
| 16 | 0:05:05 | 0:05:06 | Shuffling | 0 | 0.069 |
| 17 | 0:05:06 | 0:05:16 | Standing | 0 | 0.040 |
| 18 | 0:05:16 | 0:05:29 | Locomotion | 19 | 0.182 |
| 19 | 0:05:29 | 0:05:30 | Standing | 0 | 0.057 |
| 20 | 0:05:30 | 0:05:31 | Shuffling | 0 | 0.067 |
| 21 | 0:05:31 | 0:05:48 | Standing | 0 | 0.029 |
| 22 | 0:05:48 | 0:05:51 | Shuffling | 0 | 0.122 |
| 23 | 0:05:51 | 0:05:58 | Standing | 0 | 0.032 |
| 24 | 0:05:58 | 0:06:00 | Shuffling | 0 | 0.113 |
| 25 | 0:06:00 | 0:06:36 | Standing | 0 | 0.021 |
| 26 | 0:06:36 | 0:06:38 | Shuffling | 0 | 0.082 |
| 27 | 0:06:38 | 0:06:42 | Standing | 0 | 0.042 |
| 28 | 0:06:42 | 0:06:55 | Locomotion | 13 | 0.172 |
| 29 | 0:06:55 | 0:06:55 | Standing | 0 | 0.197 |
| 30 | 0:06:55 | 0:06:59 | Locomotion | 7 | 0.235 |
| 31 | 0:06:59 | 0:07:08 | Standing | 0 | 0.087 |
| 32 | 0:07:08 | 0:07:11 | Shuffling | 0 | 0.184 |
| 33 | 0:07:11 | 0:07:29 | Standing | 0 | 0.116 |
| 34 | 0:07:29 | 0:07:31 | Shuffling | 0 | 0.445 |
| 35 | 0:07:31 | 0:08:17 | Sitting | 0 | 0.069 |
| 36 | 0:08:17 | 0:08:18 | Standing | 0 | 0.298 |
| 37 | 0:08:18 | 0:08:21 | Shuffling | 0 | 0.212 |
| 38 | 0:08:21 | 0:08:34 | Standing | 0 | 0.048 |
| 39 | 0:08:34 | 0:08:36 | Shuffling | 0 | 0.200 |
| 40 | 0:08:36 | 0:08:47 | Standing | 0 | 0.126 |
| 41 | 0:08:47 | 0:08:49 | Shuffling | 0 | 0.238 |
| 42 | 0:08:49 | 0:09:10 | Standing | 0 | 0.050 |
| 43 | 0:09:10 | 0:09:11 | Shuffling | 0 | 0.119 |
| 44 | 0:09:11 | 0:09:27 | Standing | 0 | 0.027 |
| 45 | 0:09:27 | 0:09:29 | Shuffling | 0 | 0.169 |
| 46 | 0:09:29 | 0:09:33 | Standing | 0 | 0.042 |

# 5.4 Monitor outputs and direct observation: various examples

**Example of capturing posture transitions with *activ*PAL™ (child N0010):**

| Time | Direct observation | Direct Observation | | *activ*PAL™ time | *activ*PAL™ output |
|---|---|---|---|---|---|
| 11.53.32 | | crouch | | | sit/lie |
| 11.53.33 | | crouch | | | sit/lie |
| 11.53.34 | | crouch | | | sit/lie |
| 11.53.35 | | crouch | | | sit/lie |
| 11.53.36 | | crouch | | | sit/lie |
| 11.53.37 | | crouch | | | sit/lie |
| 11.53.38 | | crouch | | | sit/lie |
| 11.53.39 | | crouch | | | sit/lie |
| 11.53.40 | Stand | stand | | | sit/lie |
| 11.53.41 | Walk | walk | | #2008-10-06 11:53:41# | stand |
| 11.53.42 | | walk | | | stand |
| 11.53.43 | | walk | | #2008-10-06 11:53:43# | walk |
| 11.53.44 | Crouch | crouch | | #2008-10-06 11:53:44# | stand |
| 11.53.45 | | crouch | | #2008-10-06 11:53:45# | sit/lie |
| 11.53.46 | Stand | stand | | | sit/lie |
| 11.53.47 | Walk | walk | | #2008-10-06 11:53:47# | stand |
| 11.53.48 | | walk | | #2008-10-06 11:53:48# | walk |
| 11.53.49 | | walk | | | walk |
| 11.53.50 | | walk | | | walk |
| 11.53.51 | | walk | | | walk |
| 11.53.52 | | walk | | | walk |
| 11.53.53 | | walk | | | walk |
| 11.53.54 | Crouch | crouch | | #2008-10-06 11:53:54# | stand |
| 11.53.55 | | crouch | | #2008-10-06 11:53:55# | sit/lie |
| 11.53.56 | | crouch | | | sit/lie |
| 11.53.57 | | crouch | | | sit/lie |
| 11.53.58 | | crouch | | | sit/lie |
| 11.53.59 | | crouch | | | sit/lie |
| 11.54.00 | | crouch | | | sit/lie |
| 11.54.01 | Stand | stand | | | sit/lie |
| 11.54.02 | | stand | | #2008-10-06 11:54:02# | stand |
| 11.54.03 | | stand | | #2008-10-06 11:54:03# | walk |
| 11.54.04 | Walk | walk | | | walk |
| 11.54.05 | | walk | | | walk |
| 11.54.06 | Crouch | crouch | | | walk |
| 11.54.07 | | crouch | | | walk |
| 11.54.08 | | crouch | | #2008-10-06 11:54:08# | stand |
| 11.54.081 | | crouch | | #2008-10-06 11:54:08# | sit/lie |
| 11.54.09 | | crouch | | | sit/lie |
| 11.54.10 | | crouch | | | sit/lie |
| 11.54.11 | | crouch | | | sit/lie |

| | | | | | |
|---|---|---|---|---|---|
| 11.54.12 | | crouch | | | sit/lie |
| 11.54.13 | | crouch | | | sit/lie |
| 11.54.14 | | crouch | | | sit/lie |
| 11.54.15 | | crouch | | | sit/lie |
| 11.54.16 | | crouch | | | sit/lie |
| 11.54.17 | | crouch | | | sit/lie |
| 11.54.18 | | crouch | | | sit/lie |
| 11.54.19 | | crouch | | | sit/lie |
| 11.54.20 | | crouch | | | sit/lie |
| 11.54.21 | | crouch | | | sit/lie |
| 11.54.22 | stand | stand | | | sit/lie |
| 11.54.23 | | stand | | #2008-10-06 11:54:23# | stand |
| 11.54.24 | | stand | | | stand |
| 11.54.25 | | stand | | | stand |
| 11.54.26 | | stand | | | stand |
| 11.54.27 | Run | run | | | stand |
| 11.54.28 | | run | | #2008-10-06 11:54:28# | walk |
| 11.54.29 | | run | | | walk |
| 11.54.30 | | run | | | walk |
| 11.54.31 | | run | | | walk |
| 11.54.32 | | run | | | walk |
| 11.54.33 | | run | | | walk |
| 11.54.34 | | run | | | walk |

**Example output DynaPort MicroMod output with direct observation, child N0016:**

| Time | Direct obser-vation | Direct observation | | Time elapse since start of DynaPort measurement | | DynaPort MicroMod output category |
|---|---|---|---|---|---|---|
| 11.07.00 | stand | stand | | 00:50:43 | | Shuffling |
| 11.07.01 | | stand | | 00:50:44 | | Shuffling |
| 11.07.02 | | stand | | 00:50:45 | | Shuffling |
| 11.07.03 | | stand | | 00:50:46 | | Shuffling |
| 11.07.04 | | stand | | 00:50:47 | 00:50:50 | Standing |
| 11.07.05 | | stand | | 00:50:48 | | Standing |
| 11.07.06 | | stand | | 00:50:49 | | Standing |
| 11.07.07 | | stand | | 00:50:50 | 00:50:54 | Shuffling |
| 11.07.08 | | stand | | 00:50:51 | | Shuffling |
| 11.07.09 | | stand | | 00:50:52 | | Shuffling |
| 11.07.10 | Sit | sit | | 00:50:53 | | Shuffling |
| 11.07.11 | | sit | | 00:50:54 | 00:50:54 | Standing |
| 11.07.12 | | sit | | 00:50:55 | | Sitting |
| 11.07.13 | | sit | | 00:50:56 | | Sitting |

| | | | | | | |
|---|---|---|---|---|---|---|
| 11.07.14 | | sit | | 00:50:57 | | Sitting |
| 11.07.15 | | sit | | 00:50:58 | | Sitting |
| 11.07.16 | | sit | | 00:50:59 | | Sitting |
| 11.07.17 | | sit | | 00:51:00 | | Sitting |
| 11.07.18 | | sit | | 00:51:01 | | Sitting |
| 11.07.19 | | sit | | 00:51:02 | | Sitting |
| 11.07.20 | | sit | | 00:51:03 | | Sitting |
| 11.07.21 | | sit | | 00:51:04 | | Sitting |
| 11.07.22 | | sit | | 00:51:05 | 00:51:06 | Standing |
| 11.07.23 | Stand | stand | | 00:51:06 | 00:51:09 | Shuffling |
| 11.07.24 | Walk | walk | | 00:51:07 | | Shuffling |
| 11.07.25 | | walk | | 00:51:08 | | Shuffling |
| 11.07.26 | | walk | | 00:51:09 | 00:51:09 | Standing |
| 11.07.26 | | walk | | 00:51:09 | 00:51:13 | Locomotion |
| 11.07.27 | | walk | | 00:51:10 | | Locomotion |
| 11.07.28 | | walk | | 00:51:11 | | Locomotion |
| 11.07.29 | | walk | | 00:51:12 | | Locomotion |
| 11.07.30 | | walk | | 00:51:13 | 00:52:03 | Standing |
| 11.07.31 | Stand | stand | | 00:51:14 | | Standing |
| 11.07.32 | | stand | | 00:51:15 | | Standing |
| 11.07.33 | | stand | | 00:51:16 | | Standing |
| 11.07.34 | | stand | | 00:51:17 | | Standing |
| 11.07.35 | | stand | | 00:51:18 | | Standing |
| 11.07.36 | | stand | | 00:51:19 | | Standing |
| 11.07.37 | | stand | | 00:51:20 | | Standing |
| 11.07.38 | | stand | | 00:51:21 | | Standing |
| 11.07.39 | | stand | | 00:51:22 | | Standing |
| 11.07.40 | | stand | | 00:51:23 | | Standing |
| 11.07.41 | | stand | | 00:51:24 | | Standing |
| 11.07.42 | | stand | | 00:51:25 | | Standing |
| 11.07.43 | | stand | | 00:51:26 | | Standing |
| 11.07.44 | | stand | | 00:51:27 | | Standing |
| 11.07.45 | | stand | | 00:51:28 | | Standing |
| 11.07.46 | | stand | | 00:51:29 | | Standing |
| 11.07.47 | | stand | | 00:51:30 | | Standing |
| 11.07.48 | | stand | | 00:51:31 | | Standing |
| 11.07.49 | | stand | | 00:51:32 | | Standing |
| 11.07.50 | | stand | | 00:51:33 | | Standing |
| 11.07.51 | | stand | | 00:51:34 | | Standing |
| 11.07.52 | | stand | | 00:51:35 | | Standing |
| 11.07.53 | | stand | | 00:51:36 | | Standing |
| 11.07.54 | | stand | | 00:51:37 | | Standing |
| 11.07.55 | | stand | | 00:51:38 | | Standing |
| 11.07.56 | | stand | | 00:51:39 | | Standing |
| 11.07.57 | | stand | | 00:51:40 | | Standing |
| 11.07.58 | | stand | | 00:51:41 | | Standing |
| 11.07.59 | | stand | | 00:51:42 | | Standing |
| 11.08.00 | | stand | | 00:51:43 | | Standing |
| 11.08.01 | | stand | | 00:51:44 | | Standing |
| 11.08.02 | | stand | | 00:51:45 | | Standing |
| 11.08.03 | | stand | | 00:51:46 | | Standing |
| 11.08.04 | | stand | | 00:51:47 | | Standing |

| | | | | | | |
|---|---|---|---|---|---|---|
| 11.08.05 | | stand | | 00:51:48 | | Standing |
| 11.08.06 | | stand | | 00:51:49 | | Standing |
| 11.08.07 | | stand | | 00:51:50 | | Standing |
| 11.08.08 | | stand | | 00:51:51 | | Standing |
| 11.08.09 | | stand | | 00:51:52 | | Standing |
| 11.08.10 | | stand | | 00:51:53 | | Standing |
| 11.08.11 | | stand | | 00:51:54 | | Standing |
| 11.08.12 | | stand | | 00:51:55 | | Standing |
| 11.08.13 | | stand | | 00:51:56 | | Standing |
| 11.08.14 | | stand | | 00:51:57 | | Standing |
| 11.08.15 | | stand | | 00:51:58 | | Standing |
| 11.08.16 | | stand | | 00:51:59 | | Standing |
| 11.08.17 | | stand | | 00:52:00 | | Standing |
| 11.08.18 | | stand | | 00:52:01 | | Standing |
| 11.08.19 | | stand | | 00:52:02 | | Standing |
| 11.08.20 | | stand | | 00:52:03 | 00:52:05 | Shuffling |
| 11.08.21 | Walk | walk | | 00:52:04 | | Shuffling |
| 11.08.22 | | walk | | 00:52:05 | 00:52:06 | Standing |
| 11.08.23 | | walk | | 00:52:06 | 00:52:10 | Locomotion |
| 11.08.24 | | walk | | 00:52:07 | | Locomotion |
| 11.08.25 | | walk | | 00:52:08 | | Locomotion |
| 11.08.26 | | walk | | 00:52:09 | | Locomotion |
| 11.08.27 | | walk | | 00:52:10 | 00:52:14 | Standing |
| 11.08.28 | | walk | | 00:52:11 | | Standing |

**Further example output DynaPort MicroMod output with direct observation, child N0016:**

| Time | Direct obser-vation | Direct observation | | Time elapse since start of DynaPort measurement | | DynaPort MicroMod output category |
|---|---|---|---|---|---|---|
| 10.53.36 | Walk | walk | | 00:37:19 | 00:37:24 | Shuffling |
| 10.53.37 | | walk | | 00:37:20 | | Shuffling |
| 10.53.38 | | walk | | 00:37:21 | | Shuffling |
| 10.53.39 | | walk | | 00:37:22 | | Shuffling |
| 10.53.40 | stand | stand | | 00:37:23 | | Shuffling |
| 10.53.41 | | stand | | 00:37:24 | 00:37:32 | Standing |
| 10.53.42 | | stand | | 00:37:25 | | Standing |
| 10.53.43 | | stand | | 00:37:26 | | Standing |
| 10.53.44 | | stand | | 00:37:27 | | Standing |
| 10.53.45 | | stand | | 00:37:28 | | Standing |
| 10.53.46 | | stand | | 00:37:29 | | Standing |
| 10.53.47 | | stand | | 00:37:30 | | Standing |
| 10.53.48 | | stand | | 00:37:31 | | Standing |
| 10.53.49 | | stand | | 00:37:32 | 00:37:34 | Shuffling |
| 10.53.50 | | stand | | 00:37:33 | | Shuffling |
| 10.53.51 | | stand | | 00:37:34 | 00:37:35 | Standing |
| 10.53.52 | | stand | | 00:37:35 | 00:37:39 | Locomotion |
| 10.53.53 | Walk | walk | | 00:37:36 | | Locomotion |
| 10.53.54 | | walk | | 00:37:37 | | Locomotion |
| 10.53.55 | | walk | | 00:37:38 | | Locomotion |
| 10.53.56 | | walk | | 00:37:39 | 00:37:40 | Standing |

| | | | | | | |
|---|---|---|---|---|---|---|
| 10.53.57 | | walk | | 00:37:40 | 00:37:41 | Shuffling |
| 10.53.58 | Stand | stand | | 00:37:41 | 00:37:44 | Standing |
| 10.53.59 | | stand | | 00:37:42 | | Standing |
| 10.54.00 | | stand | | 00:37:43 | | Standing |
| 10.54.01 | | stand | | 00:37:44 | 00:37:46 | Shuffling |
| 10.54.02 | | stand | | 00:37:45 | | Shuffling |
| 10.54.03 | | stand | | 00:37:46 | 00:37:48 | Standing |
| 10.54.04 | | stand | | 00:37:47 | | Standing |
| 10.54.05 | | stand | | 00:37:48 | 00:37:55 | Locomotion |
| 10.54.06 | Walk | walk | | 00:37:49 | | Locomotion |
| 10.54.07 | | walk | | 00:37:50 | | Locomotion |
| 10.54.08 | | walk | | 00:37:51 | | Locomotion |
| 10.54.09 | | walk | | 00:37:52 | | Locomotion |
| 10.54.10 | | walk | | 00:37:53 | | Locomotion |
| 10.54.11 | Stand | stand | | 00:37:54 | | Locomotion |
| 10.54.12 | | stand | | 00:37:55 | 00:37:58 | Standing |
| 10.54.13 | | stand | | 00:37:56 | | Standing |
| 10.54.14 | | stand | | 00:37:57 | | Standing |
| 10.54.15 | | stand | | 00:37:58 | 00:38:09 | Locomotion |
| 10.54.16 | Walk | walk | | 00:37:59 | | Locomotion |
| 10.54.17 | | walk | | 00:38:00 | | Locomotion |
| 10.54.18 | | walk | | 00:38:01 | | Locomotion |
| 10.54.19 | | walk | | 00:38:02 | | Locomotion |
| 10.54.20 | | walk | | 00:38:03 | | Locomotion |
| 10.54.21 | | walk | | 00:38:04 | | Locomotion |
| 10.54.22 | | walk | | 00:38:05 | | Locomotion |
| 10.54.23 | | walk | | 00:38:06 | | Locomotion |
| 10.54.24 | | walk | | 00:38:07 | | Locomotion |
| 10.54.25 | | walk | | 00:38:08 | | Locomotion |
| 10.54.26 | | walk | | 00:38:09 | 00:38:09 | Standing |
| 10.54.27 | Stand | stand | | 00:38:10 | | Shuffling |
| 10.54.28 | | stand | | 00:38:11 | 00:38:22 | Standing |
| 10.54.29 | | stand | | 00:38:12 | | Standing |
| 10.54.30 | | stand | | 00:38:13 | | Standing |
| 10.54.31 | | stand | | 00:38:14 | | Standing |
| 10.54.32 | | stand | | 00:38:15 | | Standing |
| 10.54.33 | | stand | | 00:38:16 | | Standing |
| 10.54.34 | | stand | | 00:38:17 | | Standing |
| 10.54.35 | | stand | | 00:38:18 | | Standing |
| 10.54.36 | | stand | | 00:38:19 | | Standing |
| 10.54.37 | | stand | | 00:38:20 | | Standing |
| 10.54.38 | | stand | | 00:38:21 | | Standing |
| 10.54.39 | | stand | | 00:38:22 | 00:38:34 | Locomotion |
| 10.54.40 | Walk | walk | | 00:38:23 | | Locomotion |
| 10.54.41 | | walk | | 00:38:24 | | Locomotion |
| 10.54.42 | | walk | | 00:38:25 | | Locomotion |
| 10.54.43 | | walk | | 00:38:26 | | Locomotion |
| 10.54.44 | | walk | | 00:38:27 | | Locomotion |
| 10.54.45 | | walk | | 00:38:28 | | Locomotion |
| 10.54.46 | | walk | | 00:38:29 | | Locomotion |
| 10.54.47 | | walk | | 00:38:30 | | Locomotion |
| 10.54.48 | | walk | | 00:38:31 | | Locomotion |
| 10.54.49 | | walk | | 00:38:32 | | Locomotion |
| 10.54.50 | Stand | stand | | 00:38:33 | | Locomotion |

| | | | | | | |
|---|---|---|---|---|---|---|
| 10.54.51 | | stand | | 00:38:34 | 00:38:43 | Standing |
| 10.54.52 | | stand | | 00:38:35 | | Standing |
| 10.54.53 | | stand | | 00:38:36 | | Standing |
| 10.54.54 | | stand | | 00:38:37 | | Standing |
| 10.54.55 | | stand | | 00:38:38 | | Standing |
| 10.54.56 | | stand | | 00:38:39 | | Standing |
| 10.54.57 | | stand | | 00:38:40 | | Standing |
| 10.54.58 | | stand | | 00:38:41 | | Standing |
| 10.54.59 | | stand | | 00:38:42 | | Standing |
| 10.55.00 | Walk | walk | | 00:38:43 | 00:38:47 | Locomotion |
| 10.55.01 | | walk | | 00:38:44 | | Locomotion |
| 10.55.02 | | walk | | 00:38:45 | | Locomotion |
| 10.55.03 | Stand | stand | | 00:38:46 | | Locomotion |
| 10.55.04 | | stand | | 00:38:47 | 00:38:50 | Standing |
| 10.55.05 | | stand | | 00:38:48 | | Standing |
| 10.55.06 | | stand | | 00:38:49 | | Standing |
| 10.55.07 | | stand | | 00:38:50 | 00:38:52 | Shuffling |
| 10.55.08 | | stand | | 00:38:51 | | Shuffling |
| 10.55.09 | | stand | | 00:38:52 | 00:38:56 | Standing |
| 10.55.10 | | stand | | 00:38:53 | | Standing |
| 10.55.11 | | stand | | 00:38:54 | | Standing |
| 10.55.12 | | stand | | 00:38:55 | | Standing |
| 10.55.13 | | stand | | 00:38:56 | 00:39:02 | Shuffling |
| 10.55.14 | | stand | | 00:38:57 | | Shuffling |
| 10.55.15 | | stand | | 00:38:58 | | Shuffling |
| 10.55.16 | | stand | | 00:38:59 | | Shuffling |
| 10.55.17 | | stand | | 00:39:00 | | Shuffling |
| 10.55.18 | | stand | | 00:39:01 | | Shuffling |
| 10.55.19 | | stand | | 00:39:02 | 00:39:09 | Standing |
| 10.55.20 | | stand | | 00:39:03 | | Standing |
| 10.55.21 | | stand | | 00:39:04 | | Standing |
| 10.55.22 | | stand | | 00:39:05 | | Standing |
| 10.55.23 | | stand | | 00:39:06 | | Standing |
| 10.55.24 | | stand | | 00:39:07 | | Standing |
| 10.55.25 | Walk | walk | | 00:39:08 | | Standing |
| 10.55.26 | | walk | | 00:39:09 | 00:39:12 | Shuffling |

**Example output DynaPort MicroMod output with direct observation, child N0017 (below):**

| Time | Direct obser-vation | Direct observation | | Time elapse since start of DynaPort measurement | | DynaPort MicroMod output category |
|---|---|---|---|---|---|---|
| 12.33.45 | | stand | | 00:54:28 | | Standing |
| 12.33.46 | | stand | | 00:54:29 | | Standing |
| 12.33.47 | | stand | | 00:54:30 | | Standing |
| 12.33.48 | | stand | | 00:54:31 | | Standing |
| 12.33.49 | | stand | | 00:54:32 | | Standing |
| 12.33.50 | | stand | | 00:54:33 | | Standing |
| 12.33.51 | | stand | | 00:54:34 | | Standing |
| 12.33.52 | | stand | | 00:54:35 | | Standing |
| 12.33.53 | | stand | | 00:54:36 | | Standing |

| | | | | | | |
|---|---|---|---|---|---|---|
| 12.33.54 | | stand | | 00:54:37 | 00:54:42 | Locomotion |
| 12.33.55 | Walk | walk | | 00:54:38 | | Locomotion |
| 12.33.56 | | walk | | 00:54:39 | | Locomotion |
| 12.33.57 | | walk | | 00:54:40 | | Locomotion |
| 12.33.58 | | walk | | 00:54:41 | | Locomotion |
| 12.33.59 | | walk | | 00:54:42 | 00:54:42 | Standing |
| 12.33.59 | | walk | | 00:54:42 | 00:54:49 | Locomotion |
| 12.34.00 | | walk | | 00:54:43 | | Locomotion |
| 12.34.01 | | walk | | 00:54:44 | | Locomotion |
| 12.34.02 | | walk | | 00:54:45 | | Locomotion |
| 12.34.03 | | walk | | 00:54:46 | | Locomotion |
| 12.34.04 | | walk | | 00:54:47 | | Locomotion |
| 12.34.05 | | walk | | 00:54:48 | | Locomotion |
| 12.34.06 | Sit on floor, legs in front | sit | | 00:54:49 | 00:54:50 | Sitting |
| 12.34.07 | | sit | | 00:54:50 | 01:09:27 | Lying |
| 12.34.08 | Lying on back, knees up | lie | | 00:54:51 | | Lying |
| 12.34.09 | | lie | | 00:54:52 | | Lying |
| 12.34.10 | | lie | | 00:54:53 | | Lying |
| 12.34.11 | | lie | | 00:54:54 | | Lying |
| 12.34.12 | | lie | | 00:54:55 | | Lying |
| 12.34.13 | | lie | | 00:54:56 | | Lying |
| 12.34.14 | | lie | | 00:54:57 | | Lying |
| 12.34.15 | | lie | | 00:54:58 | | Lying |
| 12.34.16 | | lie | | 00:54:59 | | Lying |
| 12.34.17 | | lie | | 00:55:00 | | Lying |
| 12.34.18 | | lie | | 00:55:01 | | Lying |
| 12.34.19 | | lie | | 00:55:02 | | Lying |

**Example output DynaPort MicroMod output with direct observation. DynaPort not always capturing sitting, child N0002 (below):**

| Time | Direct obser-vation | Direct observation | | Time elapse since start of DynaPort measurement | | DynaPort MicroMod output category |
|---|---|---|---|---|---|---|
| 10.16.23 | Walk | walk | | 00:53:22 | | Locomotion |
| 10.16.24 | | walk | | 00:53:23 | | Locomotion |
| 10.16.25 | | walk | | 00:53:24 | | Locomotion |
| 10.16.26 | | walk | | 00:53:25 | | Locomotion |
| 10.16.27 | | walk | | 00:53:26 | | Locomotion |
| 10.16.28 | | walk | | 00:53:27 | | Locomotion |
| 10.16.29 | | walk | | 00:53:28 | | Locomotion |

| | | | | | | |
|---|---|---|---|---|---|---|
| 10.16.30 | | walk | | 00:53:29 | | Locomotion |
| 10.16.31 | | walk | | 00:53:30 | | Locomotion |
| 10.16.32 | | walk | | 00:53:31 | | Locomotion |
| 10.16.33 | | walk | | 00:53:32 | | Locomotion |
| 10.16.34 | | walk | | 00:53:33 | | Locomotion |
| 10.16.35 | | walk | | 00:53:34 | | Locomotion |
| 10.16.36 | sit | sit | | 00:53:35 | | Locomotion |
| 10.16.37 | | sit | | 00:53:36 | 00:53:36 | Standing |
| 10.16.38 | | sit | | 00:53:37 | | Shuffling |
| 10.16.39 | | sit | | 00:53:38 | 00:53:40 | Standing |
| 10.16.40 | | sit | | 00:53:39 | | Standing |
| 10.16.41 | | sit | | 00:53:40 | 00:53:41 | Shuffling |
| 10.16.42 | Stand | stand | | 00:53:41 | 00:53:45 | Standing |
| 10.16.43 | | stand | | 00:53:42 | | Standing |
| 10.16.44 | | stand | | 00:53:43 | | Standing |
| 10.16.45 | | stand | | 00:53:44 | | Standing |
| 10.16.46 | | stand | | 00:53:45 | 00:53:49 | Shuffling |
| 10.16.47 | sit | sit | | 00:53:46 | | Shuffling |
| 10.16.48 | | sit | | 00:53:47 | | Shuffling |
| 10.16.49 | | sit | | 00:53:48 | | Shuffling |
| 10.16.50 | | sit | | 00:53:49 | 00:54:03 | Sitting |
| 10.16.51 | | sit | | 00:53:50 | | Sitting |
| 10.16.52 | | sit | | 00:53:51 | | Sitting |
| 10.16.53 | | sit | | 00:53:52 | | Sitting |
| 10.16.54 | | sit | | 00:53:53 | | Sitting |
| 10.16.55 | | sit | | 00:53:54 | | Sitting |
| 10.16.56 | | sit | | 00:53:55 | | Sitting |
| 10.16.57 | | sit | | 00:53:56 | | Sitting |
| 10.16.58 | | sit | | 00:53:57 | | Sitting |
| 10.16.59 | | sit | | 00:53:58 | | Sitting |
| 10.17.00 | | sit | | 00:53:59 | | Sitting |
| 10.17.01 | | sit | | 00:54:00 | | Sitting |
| 10.17.02 | | sit | | 00:54:01 | | Sitting |
| 10.17.03 | Stand | stand | | 00:54:02 | | Sitting |
| 10.17.04 | | stand | | 00:54:03 | 00:54:04 | Standing |
| 10.17.05 | | stand | | 00:54:04 | 00:54:06 | Shuffling |
| 10.17.06 | sit | sit | | 00:54:05 | | Shuffling |
| 10.17.07 | | sit | | 00:54:06 | 00:54:14 | Standing |
| 10.17.08 | | sit | | 00:54:07 | | Standing |
| 10.17.09 | | sit | | 00:54:08 | | Standing |
| 10.17.10 | | sit | | 00:54:09 | | Standing |
| 10.17.11 | | sit | | 00:54:10 | | Standing |

| | | | | | | |
|---|---|---|---|---|---|---|
| 10.17.12 | | sit | | 00:54:11 | | Standing |
| 10.17.13 | | sit | | 00:54:12 | | Standing |
| 10.17.14 | | sit | | 00:54:13 | | Standing |
| 10.17.15 | | sit | | 00:54:14 | 00:54:16 | Shuffling |
| 10.17.16 | Stand | stand | | 00:54:15 | | Shuffling |
| 10.17.17 | | stand | | 00:54:16 | 00:55:51 | Sitting |
| 10.17.18 | | stand | | 00:54:17 | | Sitting |
| 10.17.19 | | stand | | 00:54:18 | | Sitting |
| 10.17.20 | | stand | | 00:54:19 | | Sitting |
| 10.17.21 | | stand | | 00:54:20 | | Sitting |
| 10.17.22 | sit | sit | | 00:54:21 | | Sitting |
| 10.17.23 | | sit | | 00:54:22 | | Sitting |
| 10.17.24 | | sit | | 00:54:23 | | Sitting |
| 10.17.25 | | sit | | 00:54:24 | | Sitting |
| 10.17.26 | | sit | | 00:54:25 | | Sitting |
| 10.17.27 | | sit | | 00:54:26 | | Sitting |
| 10.17.28 | | sit | | 00:54:27 | | Sitting |
| 10.17.29 | | sit | | 00:54:28 | | Sitting |
| 10.17.30 | | sit | | 00:54:29 | | Sitting |
| 10.17.31 | | sit | | 00:54:30 | | Sitting |
| 10.17.32 | | sit | | 00:54:31 | | Sitting |
| 10.17.33 | | sit | | 00:54:32 | | Sitting |
| 10.17.34 | | sit | | 00:54:33 | | Sitting |
| 10.17.35 | | sit | | 00:54:34 | | Sitting |
| 10.17.36 | | sit | | 00:54:35 | | Sitting |
| 10.17.37 | | sit | | 00:54:36 | | Sitting |
| 10.17.38 | | sit | | 00:54:37 | | Sitting |
| 10.17.39 | | sit | | 00:54:38 | | Sitting |
| 10.17.40 | | sit | | 00:54:39 | | Sitting |
| 10.17.41 | | sit | | 00:54:40 | | Sitting |
| 10.17.42 | | sit | | 00:54:41 | | Sitting |
| 10.17.43 | | sit | | 00:54:42 | | Sitting |
| 10.17.44 | | sit | | 00:54:43 | | Sitting |
| 10.17.45 | | sit | | 00:54:44 | | Sitting |
| 10.17.46 | | sit | | 00:54:45 | | Sitting |
| 10.17.47 | | sit | | 00:54:46 | | Sitting |
| 10.17.48 | | sit | | 00:54:47 | | Sitting |
| 10.17.49 | | sit | | 00:54:48 | | Sitting |
| 10.17.50 | | sit | | 00:54:49 | | Sitting |
| 10.17.51 | | sit | | 00:54:50 | | Sitting |
| 10.17.52 | | sit | | 00:54:51 | | Sitting |
| 10.17.53 | | sit | | 00:54:52 | | Sitting |

| | | | | | | |
|---|---|---|---|---|---|---|
| 10.17.54 | | sit | | 00:54:53 | | Sitting |
| 10.17.55 | | sit | | 00:54:54 | | Sitting |
| 10.17.56 | | sit | | 00:54:55 | | Sitting |
| 10.17.57 | | sit | | 00:54:56 | | Sitting |
| 10.17.58 | | sit | | 00:54:57 | | Sitting |
| 10.17.59 | | sit | | 00:54:58 | | Sitting |
| 10.18.00 | | sit | | 00:54:59 | | Sitting |
| 10.18.01 | | sit | | 00:55:00 | | Sitting |
| 10.18.02 | | sit | | 00:55:01 | | Sitting |
| 10.18.03 | | sit | | 00:55:02 | | Sitting |
| 10.18.04 | | sit | | 00:55:03 | | Sitting |
| 10.18.05 | | sit | | 00:55:04 | | Sitting |
| 10.18.06 | | sit | | 00:55:05 | | Sitting |
| 10.18.07 | | sit | | 00:55:06 | | Sitting |
| 10.18.08 | | sit | | 00:55:07 | | Sitting |
| 10.18.09 | | sit | | 00:55:08 | | Sitting |
| 10.18.10 | | sit | | 00:55:09 | | Sitting |
| 10.18.11 | | sit | | 00:55:10 | | Sitting |
| 10.18.12 | | sit | | 00:55:11 | | Sitting |
| 10.18.13 | | sit | | 00:55:12 | | Sitting |
| 10.18.14 | | sit | | 00:55:13 | | Sitting |
| 10.18.15 | | sit | | 00:55:14 | | Sitting |
| 10.18.16 | | sit | | 00:55:15 | | Sitting |
| 10.18.17 | | sit | | 00:55:16 | | Sitting |
| 10.18.18 | | sit | | 00:55:17 | | Sitting |
| 10.18.19 | | sit | | 00:55:18 | | Sitting |
| 10.18.20 | | sit | | 00:55:19 | | Sitting |
| 10.18.21 | | sit | | 00:55:20 | | Sitting |
| 10.18.22 | | sit | | 00:55:21 | | Sitting |
| 10.18.23 | | sit | | 00:55:22 | | Sitting |
| 10.18.24 | | sit | | 00:55:23 | | Sitting |
| 10.18.25 | | sit | | 00:55:24 | | Sitting |
| 10.18.26 | | sit | | 00:55:25 | | Sitting |
| 10.18.27 | | sit | | 00:55:26 | | Sitting |
| 10.18.28 | | sit | | 00:55:27 | | Sitting |
| 10.18.29 | | sit | | 00:55:28 | | Sitting |
| 10.18.30 | | sit | | 00:55:29 | | Sitting |
| 10.18.31 | | sit | | 00:55:30 | | Sitting |
| 10.18.32 | | sit | | 00:55:31 | | Sitting |
| 10.18.33 | | sit | | 00:55:32 | | Sitting |
| 10.18.34 | | sit | | 00:55:33 | | Sitting |
| 10.18.35 | | sit | | 00:55:34 | | Sitting |

| | | | | | | |
|---|---|---|---|---|---|---|
| 10.18.36 | | sit | | 00:55:35 | | Sitting |
| 10.18.37 | | sit | | 00:55:36 | | Sitting |
| 10.18.38 | | sit | | 00:55:37 | | Sitting |
| 10.18.39 | | sit | | 00:55:38 | | Sitting |
| 10.18.40 | | sit | | 00:55:39 | | Sitting |
| 10.18.41 | | sit | | 00:55:40 | | Sitting |
| 10.18.42 | | sit | | 00:55:41 | | Sitting |
| 10.18.43 | | sit | | 00:55:42 | | Sitting |
| 10.18.44 | | sit | | 00:55:43 | | Sitting |
| 10.18.45 | | sit | | 00:55:44 | | Sitting |
| 10.18.46 | | sit | | 00:55:45 | | Sitting |
| 10.18.47 | | sit | | 00:55:46 | | Sitting |
| 10.18.48 | | sit | | 00:55:47 | | Sitting |
| 10.18.49 | | sit | | 00:55:48 | | Sitting |
| 10.18.50 | | sit | | 00:55:49 | | Sitting |
| 10.18.51 | Stand | stand | | 00:55:50 | | Sitting |
| 10.18.52 | | stand | | 00:55:51 | 00:56:09 | Standing |
| 10.18.53 | | stand | | 00:55:52 | | Standing |
| 10.18.54 | | stand | | 00:55:53 | | Standing |
| 10.18.55 | | stand | | 00:55:54 | | Standing |
| 10.18.56 | | stand | | 00:55:55 | | Standing |
| 10.18.57 | | stand | | 00:55:56 | | Standing |
| 10.18.58 | | stand | | 00:55:57 | | Standing |
| 10.18.59 | | stand | | 00:55:58 | | Standing |
| 10.19.00 | | stand | | 00:55:59 | | Standing |
| 10.19.01 | | stand | | 00:56:00 | | Standing |
| 10.19.02 | | stand | | 00:56:01 | | Standing |
| 10.19.03 | | stand | | 00:56:02 | | Standing |
| 10.19.04 | | stand | | 00:56:03 | | Standing |
| 10.19.05 | | stand | | 00:56:04 | | Standing |
| 10.19.06 | sit | sit | | 00:56:05 | | Standing |
| 10.19.07 | | sit | | 00:56:06 | | Standing |
| 10.19.08 | | sit | | 00:56:07 | | Standing |
| 10.19.09 | Stand | stand | | 00:56:08 | | Standing |
| 10.19.10 | | stand | | 00:56:09 | 00:56:11 | Shuffling |
| 10.19.11 | | stand | | 00:56:10 | | Shuffling |
| 10.19.12 | | stand | | 00:56:11 | 00:56:40 | Standing |

Examples *activ*PAL™ output and direct observation 'other' category, child N0020:

| Time | Direct observation | Direct Observation | | *activ*PAL™ time | *activ*PAL™ output |
|---|---|---|---|---|---|
| 10.17.05 | | walk | | | walk |
| 10.17.06 | | walk | | | walk |
| 10.17.07 | | walk | | | walk |
| 10.17.08 | | walk | | | walk |
| 10.17.09 | | walk | | #2008-10-21 10:17:09# | stand |
| 10.17.10 | crouch | crouch | | #2008-10-21 10:17:10# | sit/lie |
| 10.17.11 | | crouch | | | sit/lie |
| 10.17.12 | | crouch | | | sit/lie |
| 10.17.13 | | crouch | | | sit/lie |
| 10.17.14 | stand | stand | | #2008-10-21 10:17:14# | stand |
| 10.17.15 | walk | walk | | #2008-10-21 10:17:15# | walk |
| 10.17.16 | | walk | | | walk |
| 10.17.17 | | walk | | | walk |
| 10.17.18 | | walk | | | walk |
| 10.17.19 | | walk | | | walk |
| 10.17.20 | | walk | | | walk |
| 10.17.21 | | walk | | #2008-10-21 10:17:21# | stand |
| 10.17.22 | | walk | | #2008-10-21 10:17:22# | sit/lie |
| 10.17.23 | crouch | crouch | | #2008-10-21 10:17:23# | stand |
| 10.17.24 | stand | stand | | | stand |
| 10.17.25 | | stand | | | stand |
| 10.17.26 | walk | walk | | | stand |
| 10.17.27 | crouch | crouch | | #2008-10-21 10:17:27# | sit/lie |
| 10.17.28 | | crouch | | | sit/lie |
| 10.17.29 | stand | stand | | #2008-10-21 10:17:29# | stand |
| 10.17.30 | walk | walk | | | stand |
| 10.17.31 | stand | stand | | | stand |
| 10.17.32 | | stand | | | stand |
| 10.17.33 | | stand | | | stand |
| 10.17.34 | crouch | crouch | | #2008-10-21 10:17:34# | sit/lie |
| 10.17.35 | | crouch | | | sit/lie |
| 10.17.36 | kneel down | sit | | | sit/lie |
| 10.17.37 | | sit | | | sit/lie |
| 10.17.38 | | sit | | | sit/lie |
| 10.17.39 | | sit | | | sit/lie |
| 10.17.40 | | sit | | | sit/lie |
| 10.17.41 | | sit | | | sit/lie |
| 10.17.42 | | sit | | | sit/lie |
| 10.17.43 | | sit | | | sit/lie |
| 10.17.44 | | sit | | | sit/lie |
| 10.17.45 | | sit | | | sit/lie |
| 10.17.46 | | sit | | | sit/lie |
| 10.17.47 | | sit | | | sit/lie |
| 10.17.48 | kneel up | kneel up | | #2008-10-21 10:17:48# | stand |
| 10.17.49 | | kneel up | | | stand |
| 10.17.50 | stand | stand | | #2008-10-21 10:17:50# | walk |
| 10.17.51 | walk | walk | | | walk |
| 10.17.52 | | walk | | | walk |
| 10.17.53 | | walk | | | walk |

**Example DynaPort MicroMod output and direct observation 'other' category, child N0020 for same section as illustrated for *activ*PAL™ and 'other':**

| Time | Direct observation | Direct observation | | Time elapse since start of DynaPort measurement | | DynaPort MicroMod output category |
|---|---|---|---|---|---|---|
| 10.17.05 | | walk | | 00:15:39 | | Shuffling |
| 10.17.06 | | walk | | 00:15:40 | | Shuffling |
| 10.17.07 | | walk | | 00:15:41 | | Shuffling |
| 10.17.08 | | walk | | 00:15:42 | | Shuffling |
| 10.17.09 | | walk | | 00:15:43 | | Shuffling |
| 10.17.10 | crouch | crouch | | 00:15:44 | 00:15:49 | Standing |
| 10.17.11 | | crouch | | 00:15:45 | | Standing |
| 10.17.12 | | crouch | | 00:15:46 | | Standing |
| 10.17.13 | | crouch | | 00:15:47 | | Standing |
| 10.17.14 | stand | stand | | 00:15:48 | | Standing |
| 10.17.15 | walk | walk | | 00:15:49 | 00:15:53 | Shuffling |
| 10.17.16 | | walk | | 00:15:50 | | Shuffling |
| 10.17.17 | | walk | | 00:15:51 | | Shuffling |
| 10.17.18 | | walk | | 00:15:52 | | Shuffling |
| 10.17.19 | | walk | | 00:15:53 | 00:15:54 | Standing |
| 10.17.20 | | walk | | 00:15:54 | 00:15:57 | Shuffling |
| 10.17.21 | | walk | | 00:15:55 | | Shuffling |
| 10.17.22 | | walk | | 00:15:56 | | Shuffling |
| 10.17.23 | crouch | crouch | | 00:15:57 | 00:15:58 | Standing |
| 10.17.24 | stand | stand | | 00:15:58 | 00:16:02 | Locomotion |
| 10.17.25 | | stand | | 00:15:59 | | Locomotion |
| 10.17.26 | walk | walk | | 00:16:00 | | Locomotion |
| 10.17.27 | crouch | crouch | | 00:16:01 | | Locomotion |
| 10.17.28 | | crouch | | 00:16:02 | 00:16:04 | Standing |
| 10.17.29 | stand | stand | | 00:16:03 | | Standing |
| 10.17.30 | walk | walk | | 00:16:04 | 00:16:06 | Shuffling |
| 10.17.31 | stand | stand | | 00:16:05 | | Shuffling |
| 10.17.32 | | stand | | 00:16:06 | 00:16:07 | Standing |
| 10.17.33 | | stand | | 00:16:07 | 00:16:11 | Shuffling |
| 10.17.34 | crouch | crouch | | 00:16:08 | | Shuffling |
| 10.17.35 | | crouch | | 00:16:09 | | Shuffling |
| 10.17.36 | kneel down | sit | | 00:16:10 | | Shuffling |
| 10.17.37 | | sit | | 00:16:11 | 00:16:12 | Standing |
| 10.17.38 | | sit | | 00:16:12 | 00:16:14 | Shuffling |
| 10.17.39 | | sit | | 00:16:13 | | Shuffling |
| 10.17.40 | | sit | | 00:16:14 | 00:16:15 | Standing |
| 10.17.41 | | sit | | 00:16:15 | 00:16:16 | Shuffling |
| 10.17.42 | | sit | | 00:16:16 | 00:16:22 | Standing |
| 10.17.43 | | sit | | 00:16:17 | | Standing |
| 10.17.44 | | sit | | 00:16:18 | | Standing |
| 10.17.45 | | sit | | 00:16:19 | | Standing |
| 10.17.46 | | sit | | 00:16:20 | | Standing |
| 10.17.47 | | sit | | 00:16:21 | | Standing |
| 10.17.48 | kneel up | kneel up | | 00:16:22 | 00:16:24 | Shuffling |
| 10.17.49 | | kneel up | | 00:16:23 | | Shuffling |

| | | | | | | |
|---|---|---|---|---|---|---|
| 10.17.50 | stand | stand | | 00:16:24 | 00:16:25 | Standing |
| 10.17.51 | walk | walk | | 00:16:25 | 00:16:26 | Shuffling |
| 10.17.52 | | walk | | 00:16:26 | 00:16:28 | Standing |

**Example output for *activ*PAL™ misclassifying sit and stand, N0002 (below):**

| Time | Direct observation | Direct Observation | | *activ*PAL™ time | *activ*PAL™ output |
|---|---|---|---|---|---|
| 09.46.16 | stand | stand | | | stand |
| 09.46.17 | | stand | | | stand |
| 09.46.18 | | stand | | | stand |
| 09.46.19 | | stand | | | stand |
| 09.46.20 | | stand | | | stand |
| 09.46.21 | | stand | | | stand |
| 09.46.22 | | stand | | | stand |
| 09.46.23 | | stand | | | stand |
| 09.46.24 | | stand | | | stand |
| 09.46.25 | | stand | | | stand |
| 09.46.26 | | stand | | | stand |
| 09.46.27 | | stand | | | stand |
| 09.46.28 | | stand | | | stand |
| 09.46.29 | | stand | | | stand |
| 09.46.30 | | stand | | | stand |
| 09.46.31 | | stand | | | stand |
| 09.46.32 | | stand | | | stand |
| 09.46.33 | | stand | | | stand |
| 09.46.34 | | stand | | | stand |
| 09.46.35 | | stand | | | stand |
| 09.46.36 | | stand | | | stand |
| 09.46.37 | | stand | | | stand |
| 09.46.38 | Walk | walk | | #2008-10-02 09:46:38# | walk |
| 09.46.39 | | walk | | | walk |
| 09.46.40 | | walk | | | walk |
| 09.46.41 | | walk | | | walk |
| 09.46.42 | | walk | | | walk |
| 09.46.43 | | walk | | | walk |
| 09.46.44 | | walk | | | walk |
| 09.46.45 | Stand | stand | | #2008-10-02 09:46:45# | stand |
| 09.46.46 | | stand | | | stand |
| 09.46.47 | | stand | | | stand |
| 09.46.48 | | stand | | | stand |
| 09.46.49 | | stand | | | stand |

| | | | | | |
|---|---|---|---|---|---|
| 09.46.50 | | stand | | | stand |
| 09.46.51 | | stand | | | stand |
| 09.46.52 | | stand | | | stand |
| 09.46.53 | | stand | | | stand |
| 09.46.54 | | stand | | | stand |
| 09.46.55 | | stand | | | stand |
| 09.46.56 | | stand | | | stand |
| 09.46.57 | | stand | | | stand |
| 09.46.58 | | stand | | | stand |
| 09.46.59 | | stand | | #2008-10-02 09:46:59# | walk |
| 09.47.00 | | stand | | | walk |
| 09.47.01 | | stand | | | walk |
| 09.47.02 | Walk | walk | | | walk |
| 09.47.03 | | walk | | | walk |
| 09.47.04 | | walk | | | walk |
| 09.47.05 | | walk | | | walk |
| 09.47.06 | | walk | | | walk |
| 09.47.07 | | walk | | | walk |
| 09.47.08 | | walk | | | walk |
| 09.47.09 | | walk | | | walk |
| 09.47.10 | | walk | | | walk |
| 09.47.11 | | walk | | | walk |
| 09.47.12 | | walk | | | walk |
| 09.47.13 | | walk | | #2008-10-02 09:47:13# | stand |
| 09.47.14 | stand | stand | | | stand |
| 09.47.15 | | stand | | | stand |
| 09.47.16 | | stand | | | stand |
| 09.47.17 | | stand | | | stand |
| 09.47.18 | | stand | | | stand |
| 09.47.19 | | stand | | | stand |
| 09.47.20 | | stand | | | stand |
| 09.47.21 | | stand | | | stand |
| 09.47.22 | sit | sit | | #2008-10-02 09:47:22# | sit/lie |
| 09.47.23 | | sit | | | sit/lie |
| 09.47.24 | | sit | | | sit/lie |
| 09.47.25 | | sit | | | sit/lie |
| 09.47.26 | | sit | | | sit/lie |
| 09.47.27 | | sit | | | sit/lie |
| 09.47.28 | | sit | | #2008-10-02 09:47:28# | stand |
| 09.47.29 | Stand | stand | | #2008-10-02 09:47:29# | walk |
| 09.47.291 | Walk | walk | | | walk |
| 09.47.30 | | walk | | | walk |

| | | | | | |
|---|---|---|---|---|---|
| 09.47.31 | | walk | | | walk |
| 09.47.32 | | walk | | | walk |
| 09.47.33 | | walk | | | walk |
| 09.47.34 | | walk | | | walk |
| 09.47.35 | Sit | sit | | #2008-10-02 09:47:35# | stand |
| 09.47.36 | | sit | | | stand |
| 09.47.37 | | sit | | | stand |
| 09.47.38 | | sit | | | stand |
| 09.47.39 | | sit | | | stand |
| 09.47.40 | | sit | | | stand |
| 09.47.41 | | sit | | | stand |
| 09.47.42 | | sit | | | stand |
| 09.47.43 | | sit | | | stand |
| 09.47.44 | | sit | | | stand |
| 09.47.45 | | sit | | | stand |
| 09.47.46 | | sit | | | stand |
| 09.47.47 | | sit | | | stand |
| 09.47.48 | | sit | | | stand |
| 09.47.49 | | sit | | | stand |
| 09.47.50 | | sit | | | stand |
| 09.47.51 | | sit | | | stand |
| 09.47.52 | | sit | | | stand |
| 09.47.53 | | sit | | | stand |
| 09.47.54 | | sit | | | stand |
| 09.47.55 | | sit | | | stand |
| 09.47.56 | | sit | | | stand |
| 09.47.57 | | sit | | | stand |
| 09.47.58 | | sit | | | stand |
| 09.47.59 | | sit | | | stand |
| 09.48.00 | | sit | | | stand |
| 09.48.01 | | sit | | | stand |
| 09.48.02 | | sit | | | stand |
| 09.48.03 | | sit | | | stand |
| 09.48.04 | | sit | | | stand |
| 09.48.05 | | sit | | | stand |
| 09.48.06 | | sit | | | stand |
| 09.48.07 | | sit | | | stand |
| 09.48.08 | | sit | | | stand |
| 09.48.09 | | sit | | | stand |
| 09.48.10 | | sit | | | stand |
| 09.48.11 | | sit | | | stand |
| 09.48.12 | | sit | | | stand |

| | | | | | |
|---|---|---|---|---|---|
| 09.48.13 | | sit | | | stand |
| 09.48.14 | | sit | | | stand |
| 09.48.15 | | sit | | | stand |
| 09.48.16 | | sit | | | stand |
| 09.48.17 | | sit | | | stand |
| 09.48.18 | | sit | | | stand |
| 09.48.19 | | sit | | | stand |
| 09.48.20 | | sit | | | stand |
| 09.48.21 | | sit | | | stand |
| 09.48.22 | | sit | | | stand |
| 09.48.23 | | sit | | | stand |
| 09.48.24 | | sit | | | stand |
| 09.48.25 | stand | stand | | | stand |
| 09.48.26 | walk | walk | | #2008-10-02 09:48:26# | walk |
| 09.48.27 | | walk | | | walk |
| 09.48.28 | Stand | stand | | | Walk |
| 09.48.29 | | stand | | | Walk |
| 09.48.30 | walk | walk | | | Walk |
| 09.48.31 | | walk | | | Walk |
| 09.48.32 | | walk | | | Walk |
| 09.48.33 | sit | sit | | #2008-10-02 09:48:33# | Stand |
| 09.48.331 | | sit | | #2008-10-02 09:48:33# | sit/lie |
| 09.48.34 | | sit | | | sit/lie |
| 09.48.35 | | sit | | | sit/lie |
| 09.48.36 | | sit | | #2008-10-02 09:48:36# | Stand |
| 09.48.37 | | sit | | | Stand |
| 09.48.38 | | sit | | #2008-10-02 09:48:38# | Walk |
| 09.48.39 | | sit | | | Walk |
| 09.48.40 | | sit | | | Walk |
| 09.48.41 | | sit | | | Walk |
| 09.48.42 | | sit | | #2008-10-02 09:48:42# | Stand |
| 09.48.43 | | sit | | | Stand |
| 09.48.44 | | sit | | | Stand |
| 09.48.45 | | sit | | | Stand |
| 09.48.46 | | sit | | | Stand |
| 09.48.47 | | sit | | | Stand |
| 09.48.48 | | sit | | | Stand |
| 09.48.49 | | sit | | | stand |
| 09.48.50 | | sit | | | stand |
| 09.48.51 | | sit | | | stand |
| 09.48.52 | | sit | | | stand |

| | | | | | |
|---|---|---|---|---|---|
| 09.48.53 | | sit | | | stand |
| 09.48.54 | | sit | | | stand |
| 09.48.55 | | sit | | | stand |
| 09.48.56 | | sit | | | stand |
| 09.48.57 | | sit | | | stand |
| 09.48.58 | | sit | | | stand |
| 09.48.59 | | sit | | | stand |
| 09.49.00 | | sit | | | stand |
| 09.49.01 | | sit | | | stand |
| 09.49.02 | | sit | | | stand |
| 09.49.03 | | sit | | | stand |
| 09.49.04 | | sit | | | stand |
| 09.49.05 | | sit | | | stand |
| 09.49.06 | | sit | | | stand |
| 09.49.07 | | sit | | | stand |
| 09.49.08 | | sit | | | stand |
| 09.49.09 | | sit | | | stand |
| 09.49.10 | | sit | | | stand |
| 09.49.11 | | sit | | | stand |
| 09.49.12 | | sit | | | stand |
| 09.49.13 | | sit | | | stand |
| 09.49.14 | | sit | | | stand |
| 09.49.15 | | sit | | | stand |
| 09.49.16 | | sit | | #2008-10-02 09:49:16# | sit/lie |
| 09.49.17 | | sit | | | sit/lie |
| 09.49.18 | | sit | | | sit/lie |
| 09.49.19 | | sit | | | sit/lie |
| 09.49.20 | | sit | | | sit/lie |
| 09.49.21 | | sit | | | sit/lie |
| 09.49.22 | | sit | | | sit/lie |
| 09.49.23 | | sit | | | sit/lie |
| 09.49.24 | | sit | | | sit/lie |
| 09.49.25 | | sit | | | sit/lie |
| 09.49.26 | | sit | | | sit/lie |
| 09.49.27 | | sit | | | sit/lie |
| 09.49.28 | | sit | | #2008-10-02 09:49:28# | stand |
| 09.49.29 | Stands from chair | stand | | | stand |
| 09.49.30 | | stand | | | Stand |
| 09.49.31 | sit | sit | | | stand |
| 09.49.32 | | sit | | | stand |
| 09.49.33 | | sit | | | stand |

**Further example for DynaPort MicroMod misclassifying sit, N0002 (below):**

| Time | Direct obser-vation | Direct observation | | Time elapse since start of DynaPort measurement | | DynaPort MicroMod output category |
|---|---|---|---|---|---|---|
| 09.46.55 | | stand | | 00:23:54 | | Standing |
| 09.46.56 | | stand | | 00:23:55 | | Standing |
| 09.46.57 | | stand | | 00:23:56 | 00:23:58 | Shuffling |
| 09.46.58 | | stand | | 00:23:57 | | Shuffling |
| 09.46.59 | | stand | | 00:23:58 | 00:24:01 | Standing |
| 09.47.00 | | stand | | 00:23:59 | | Standing |
| 09.47.01 | | stand | | 00:24:00 | | Standing |
| 09.47.02 | Walk | walk | | 00:24:01 | 00:24:06 | Locomotion |
| 09.47.03 | | walk | | 00:24:02 | | Locomotion |
| 09.47.04 | | walk | | 00:24:03 | | Locomotion |
| 09.47.05 | | walk | | 00:24:04 | | Locomotion |
| 09.47.06 | | walk | | 00:24:05 | | Locomotion |
| 09.47.07 | | walk | | 00:24:06 | 00:24:07 | Standing |
| 09.47.08 | | walk | | 00:24:07 | 00:24:10 | Shuffling |
| 09.47.09 | | walk | | 00:24:08 | | Shuffling |
| 09.47.10 | | walk | | 00:24:09 | | Shuffling |
| 09.47.11 | | walk | | 00:24:10 | 00:24:10 | Standing |
| 09.47.12 | | walk | | 00:24:11 | | Shuffling |
| 09.47.13 | | walk | | 00:24:12 | | Shuffling |
| 09.47.14 | stand | stand | | 00:24:13 | 00:24:26 | Standing |
| 09.47.15 | | stand | | 00:24:14 | | Standing |
| 09.47.16 | | stand | | 00:24:15 | | Standing |
| 09.47.17 | | stand | | 00:24:16 | | Standing |
| 09.47.18 | | stand | | 00:24:17 | | Standing |
| 09.47.19 | | stand | | 00:24:18 | | Standing |
| 09.47.20 | | stand | | 00:24:19 | | Standing |
| 09.47.21 | | stand | | 00:24:20 | | Standing |
| 09.47.22 | sit | sit | | 00:24:21 | | Standing |
| 09.47.23 | | sit | | 00:24:22 | | Standing |
| 09.47.24 | | sit | | 00:24:23 | | Standing |
| 09.47.25 | | sit | | 00:24:24 | | Standing |
| 09.47.26 | | sit | | 00:24:25 | | Standing |
| 09.47.27 | | sit | | 00:24:26 | 00:24:30 | Shuffling |
| 09.47.28 | | sit | | 00:24:27 | | Shuffling |
| 09.47.29 | Stand | stand | | 00:24:28 | | Shuffling |
| 09.47.291 | Walk | walk | | 00:24:28 | | Shuffling |
| 09.47.30 | | walk | | 00:24:29 | | Shuffling |

| | | | | | | |
|---|---|---|---|---|---|---|
| 09.47.31 | | walk | | 00:24:30 | 00:24:31 | Standing |
| 09.47.32 | | walk | | 00:24:31 | 00:24:34 | Shuffling |
| 09.47.33 | | walk | | 00:24:32 | | Shuffling |
| 09.47.34 | | walk | | 00:24:33 | | Shuffling |
| 09.47.35 | Sit | sit | | 00:24:34 | 00:25:23 | Standing |
| 09.47.36 | | sit | | 00:24:35 | | Standing |
| 09.47.37 | | sit | | 00:24:36 | | Standing |
| 09.47.38 | | sit | | 00:24:37 | | Standing |
| 09.47.39 | | sit | | 00:24:38 | | Standing |
| 09.47.40 | | sit | | 00:24:39 | | Standing |
| 09.47.41 | | sit | | 00:24:40 | | Standing |
| 09.47.42 | | sit | | 00:24:41 | | Standing |
| 09.47.43 | | sit | | 00:24:42 | | Standing |
| 09.47.44 | | sit | | 00:24:43 | | Standing |
| 09.47.45 | | sit | | 00:24:44 | | Standing |
| 09.47.46 | | sit | | 00:24:45 | | Standing |
| 09.47.47 | | sit | | 00:24:46 | | Standing |
| 09.47.48 | | sit | | 00:24:47 | | Standing |
| 09.47.49 | | sit | | 00:24:48 | | Standing |
| 09.47.50 | | sit | | 00:24:49 | | Standing |
| 09.47.51 | | sit | | 00:24:50 | | Standing |
| 09.47.52 | | sit | | 00:24:51 | | Standing |
| 09.47.53 | | sit | | 00:24:52 | | Standing |
| 09.47.54 | | sit | | 00:24:53 | | Standing |
| 09.47.55 | | sit | | 00:24:54 | | Standing |
| 09.47.56 | | sit | | 00:24:55 | | Standing |
| 09.47.57 | | sit | | 00:24:56 | | Standing |
| 09.47.58 | | sit | | 00:24:57 | | Standing |
| 09.47.59 | | sit | | 00:24:58 | | Standing |
| 09.48.00 | | sit | | 00:24:59 | | Standing |
| 09.48.01 | | sit | | 00:25:00 | | Standing |
| 09.48.02 | | sit | | 00:25:01 | | Standing |
| 09.48.03 | | sit | | 00:25:02 | | Standing |
| 09.48.04 | | sit | | 00:25:03 | | Standing |
| 09.48.05 | | sit | | 00:25:04 | | Standing |
| 09.48.06 | | sit | | 00:25:05 | | Standing |
| 09.48.07 | | sit | | 00:25:06 | | Standing |
| 09.48.08 | | sit | | 00:25:07 | | Standing |

| | | | | | | |
|---|---|---|---|---|---|---|
| 09.48.09 | | sit | | 00:25:08 | | Standing |
| 09.48.10 | | sit | | 00:25:09 | | Standing |
| 09.48.11 | | sit | | 00:25:10 | | Standing |
| 09.48.12 | | sit | | 00:25:11 | | Standing |
| 09.48.13 | | sit | | 00:25:12 | | Standing |
| 09.48.14 | | sit | | 00:25:13 | | Standing |
| 09.48.15 | | sit | | 00:25:14 | | Standing |
| 09.48.16 | | sit | | 00:25:15 | | Standing |
| 09.48.17 | | sit | | 00:25:16 | | Standing |
| 09.48.18 | | sit | | 00:25:17 | | Standing |
| 09.48.19 | | sit | | 00:25:18 | | Standing |
| 09.48.20 | | sit | | 00:25:19 | | Standing |
| 09.48.21 | | sit | | 00:25:20 | | Standing |
| 09.48.22 | | sit | | 00:25:21 | | Standing |
| 09.48.23 | | sit | | 00:25:22 | | Standing |
| 09.48.24 | | sit | | 00:25:23 | 00:25:27 | Shuffling |
| 09.48.25 | stand | stand | | 00:25:24 | | Shuffling |
| 09.48.26 | walk | walk | | 00:25:25 | | Shuffling |
| 09.48.27 | | walk | | 00:25:26 | | Shuffling |
| 09.48.28 | Stand | stand | | 00:25:27 | 00:25:29 | Standing |
| 09.48.29 | | stand | | 00:25:28 | | Standing |
| 09.48.30 | walk | walk | | 00:25:29 | 00:25:32 | Shuffling |
| 09.48.31 | | walk | | 00:25:30 | | Shuffling |
| 09.48.32 | | walk | | 00:25:31 | | Shuffling |
| 09.48.33 | sit | sit | | 00:25:32 | 00:26:45 | Standing |
| 09.48.34 | | sit | | 00:25:33 | | Standing |
| 09.48.35 | | sit | | 00:25:34 | | Standing |
| 09.48.36 | | sit | | 00:25:35 | | Standing |

## 5.5 Direct observation posture transition data

Tables describe the relationship between consecutive seconds for direct observation data for each child. Discordant grid pairs represent the number of transitions between these categories. For example, child N0001 has 19 sit-stand transitions, 2 kneel up to stand transitions, 4 stand-crouch transitions etc.

| N0001 | Sit | lie | stand | walk | other | crouch | kneel up | crawl | off screen |
|---|---|---|---|---|---|---|---|---|---|
| Sit | 1978 | 0 | 19 | 1 | 0 | 0 | 0 | 0 | 3 |
| Lie | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Stand | 18 | 0 | 963 | 24 | 0 | 4 | 1 | 0 | 2 |
| Walk | 3 | 0 | 23 | 181 | 0 | 0 | 0 | 0 | 0 |
| Other | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| crouch | 0 | 0 | 3 | 0 | 0 | 22 | 1 | 0 | 0 |
| Kneel up | 0 | 0 | 2 | 0 | 0 | 0 | 16 | 0 | 0 |
| Crawl | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| off screen | 2 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 175 |

| N0002 | Sit | lie | Stand | walk | other | crouch | kneel up | crawl | off screen |
|---|---|---|---|---|---|---|---|---|---|
| Sit | 1442 | 0 | 45 | 1 | 0 | 0 | 0 | 0 | 0 |
| Lie | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Stand | 38 | 0 | 1423 | 46 | 0 | 5 | 0 | 0 | 1 |
| walk | 9 | 0 | 38 | 241 | 0 | 0 | 0 | 0 | 1 |
| other | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| crouch | 0 | 0 | 4 | 0 | 0 | 8 | 1 | 0 | 0 |
| kneel up | 0 | 0 | 1 | 0 | 0 | 0 | 11 | 0 | 0 |
| crawl | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| off screen | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 30 |

| N0003 | Sit | lie | stand | walk | other | crouch | kneel up | crawl | off screen |
|---|---|---|---|---|---|---|---|---|---|
| Sit | 1358 | 0 | 8 | 0 | 0 | 0 | 0 | 0 | 0 |
| lie | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| stand | 6 | 0 | 1547 | 16 | 0 | 2 | 0 | 0 | 1 |
| walk | 1 | 0 | 12 | 188 | 0 | 0 | 0 | 0 | 9 |
| other | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| crouch | 0 | 0 | 2 | 0 | 0 | 2 | 0 | 0 | 0 |
| kneel up | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| crawl | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| off screen | 1 | 0 | 3 | 5 | 0 | 0 | 0 | 0 | 277 |

| N0004 | Sit | lie | stand | walk | other | Crouch | kneel up | crawl | off screen |
|---|---|---|---|---|---|---|---|---|---|
| Sit | 1310 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 3 |
| lie | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| stand | 5 | 0 | 1483 | 7 | 2 | 0 | 0 | 0 | 4 |
| walk | 0 | 0 | 7 | 182 | 0 | 0 | 0 | 0 | 3 |
| other | 0 | 0 | 2 | 0 | 14 | 0 | 0 | 0 | 0 |
| crouch | 0 | 0 | 1 | 0 | 0 | 4 | 0 | 0 | 0 |
| kneel up | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| crawl | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| off screen | 3 | 0 | 2 | 3 | 0 | 1 | 0 | 0 | 396 |

| N0005 | Sit | lie | stand | walk | other | crouch | kneel up | crawl | off screen |
|---|---|---|---|---|---|---|---|---|---|
| Sit | 407 | 3 | 11 | 0 | 0 | 0 | 9 | 3 | 3 |
| lie | 3 | 325 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| stand | 6 | 0 | 569 | 41 | 0 | 4 | 0 | 0 | 3 |
| walk | 7 | 0 | 26 | 707 | 3 | 1 | 3 | 2 | 13 |
| other | 5 | 0 | 2 | 1 | 67 | 0 | 0 | 0 | 0 |
| crouch | 0 | 0 | 4 | 0 | 1 | 24 | 0 | 0 | 0 |
| kneel up | 4 | 1 | 3 | 1 | 4 | 0 | 76 | 0 | 0 |
| crawl | 2 | 0 | 1 | 1 | 0 | 0 | 0 | 7 | 1 |
| off screen | 2 | 1 | 5 | 11 | 0 | 0 | 0 | 0 | 925 |

| N0006 | Sit | lie | stand | walk | other | crouch | kneel up | Crawl | off screen |
|---|---|---|---|---|---|---|---|---|---|
| Sit | 1046 | 11 | 32 | 0 | 0 | 0 | 4 | 0 | 7 |
| lie | 11 | 177 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| stand | 16 | 0 | 404 | 60 | 2 | 8 | 3 | 1 | 8 |
| walk | 8 | 1 | 39 | 983 | 1 | 4 | 2 | 0 | 22 |
| other | 3 | 0 | 0 | 0 | 9 | 0 | 1 | 0 | 0 |
| crouch | 1 | 0 | 11 | 0 | 0 | 25 | 0 | 0 | 0 |
| kneel up | 7 | 1 | 2 | 1 | 1 | 0 | 72 | 0 | 0 |
| crawl | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 3 | 0 |
| off screen | 8 | 0 | 11 | 16 | 0 | 0 | 2 | 0 | 490 |

| N0007 | Sit | lie | stand | walk | Other | crouch | kneel up | crawl | off screen |
|---|---|---|---|---|---|---|---|---|---|
| Sit | 171 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 1 |
| lie | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| stand | 2 | 0 | 3233 | 18 | 2 | 0 | 0 | 0 | 2 |
| walk | 1 | 0 | 18 | 142 | 0 | 0 | 0 | 0 | 1 |
| other | 0 | 0 | 2 | 0 | 14 | 0 | 0 | 0 | 0 |
| crouch | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| kneel up | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| crawl | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| off screen | 1 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 11 |

| N0008 | Sit | lie | stand | walk | Other | crouch | kneel up | crawl | off screen |
|---|---|---|---|---|---|---|---|---|---|
| Sit | 65 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| lie | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| stand | 0 | 0 | 3122 | 22 | 1 | 5 | 0 | 0 | 2 |
| walk | 1 | 0 | 21 | 172 | 1 | 2 | 0 | 0 | 7 |
| other | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| crouch | 0 | 0 | 7 | 0 | 0 | 8 | 0 | 0 | 0 |
| kneel up | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| crawl | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| off screen | 0 | 0 | 1 | 8 | 0 | 0 | 0 | 0 | 183 |

| N0009 | Sit | lie | stand | walk | other | crouch | kneel up | crawl | off screen |
|---|---|---|---|---|---|---|---|---|---|
| Sit | 2661 | 0 | 13 | 0 | 5 | 1 | 1 | 2 | 2 |
| lie | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| stand | 12 | 0 | 416 | 43 | 0 | 3 | 0 | 0 | 3 |
| walk | 3 | 0 | 37 | 568 | 0 | 2 | 0 | 0 | 12 |
| other | 4 | 0 | 0 | 0 | 41 | 0 | 0 | 1 | 0 |
| crouch | 0 | 0 | 6 | 0 | 0 | 6 | 0 | 0 | 0 |
| kneel up | 1 | 0 | 1 | 0 | 0 | 0 | 2 | 0 | 0 |
| crawl | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 9 | 0 |
| off screen | 2 | 0 | 3 | 10 | 0 | 0 | 0 | 0 | 956 |

| N0010 | Sit | lie | Stand | walk | other | crouch | kneel up | crawl | off screen |
|---|---|---|---|---|---|---|---|---|---|
| Sit | 803 | 0 | 3 | 0 | 1 | 0 | 2 | 0 | 4 |
| lie | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| stand | 0 | 0 | 666 | 70 | 1 | 2 | 0 | 0 | 4 |
| walk | 6 | 0 | 55 | 926 | 1 | 8 | 0 | 0 | 26 |
| other | 0 | 0 | 3 | 0 | 36 | 0 | 0 | 0 | 0 |
| crouch | 0 | 0 | 10 | 0 | 0 | 85 | 0 | 0 | 0 |
| kneel up | 0 | 0 | 0 | 1 | 0 | 0 | 55 | 0 | 1 |
| crawl | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| off screen | 5 | 0 | 5 | 25 | 0 | 0 | 0 | 0 | 867 |

| N0011 | Sit | lie | stand | walk | other | crouch | kneel up | crawl | off screen |
|---|---|---|---|---|---|---|---|---|---|
| Sit | 3234 | 1 | 15 | 0 | 0 | 0 | 1 | 0 | 4 |
| lie | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| stand | 13 | 0 | 329 | 11 | 0 | 0 | 0 | 0 | 2 |
| walk | 3 | 0 | 9 | 108 | 0 | 0 | 0 | 0 | 4 |
| other | 1 | 0 | 1 | 0 | 5 | 0 | 0 | 0 | 0 |
| crouch | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| kneel up | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 |
| crawl | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 2 | 0 |
| off screen | 4 | 0 | 3 | 3 | 0 | 0 | 0 | 0 | 159 |

| N0012 | Sit | lie | stand | Walk | other | crouch | kneel up | crawl | off screen |
|---|---|---|---|---|---|---|---|---|---|
| Sit | 1626 | 3 | 24 | 0 | 4 | 0 | 1 | 7 | 7 |
| lie | 3 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| stand | 16 | 0 | 1145 | 31 | 2 | 4 | 4 | 0 | 1 |
| walk | 7 | 0 | 17 | 233 | 2 | 2 | 2 | 0 | 4 |
| other | 4 | 0 | 4 | 0 | 51 | 0 | 0 | 0 | 0 |
| crouch | 0 | 0 | 6 | 0 | 0 | 9 | 0 | 0 | 0 |
| kneel up | 0 | 0 | 6 | 1 | 0 | 0 | 135 | 0 | 0 |
| crawl | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 9 | 0 |
| off screen | 8 | 0 | 2 | 2 | 0 | 0 | 0 | 0 | 237 |

| N0013 | Sit | lie | stand | walk | other | crouch | kneel up | crawl | Off screen |
|---|---|---|---|---|---|---|---|---|---|
| Sit | 2097 | 0 | 21 | 0 | 1 | 0 | 6 | 1 | 3 |
| lie | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| stand | 15 | 0 | 866 | 38 | 0 | 0 | 2 | 0 | 3 |
| walk | 2 | 0 | 33 | 328 | 0 | 1 | 0 | 0 | 4 |
| other | 0 | 0 | 0 | 0 | 6 | 0 | 1 | 0 | 0 |
| crouch | 1 | 0 | 1 | 0 | 0 | 9 | 0 | 0 | 0 |
| kneel up | 8 | 0 | 1 | 0 | 0 | 0 | 129 | 0 | 0 |
| crawl | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 |
| off screen | 4 | 0 | 3 | 2 | 0 | 0 | 0 | 0 | 13 |

| N0014 | Sit | lie | stand | walk | other | crouch | kneel up | crawl | Off screen |
|---|---|---|---|---|---|---|---|---|---|
| Sit | 1381 | 0 | 5 | 0 | 3 | 0 | 0 | 0 | 2 |
| Lie | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| stand | 3 | 0 | 422 | 48 | 0 | 2 | 0 | 0 | 6 |
| walk | 1 | 0 | 38 | 689 | 0 | 5 | 0 | 0 | 26 |
| other | 3 | 0 | 0 | 0 | 13 | 0 | 0 | 0 | 0 |
| crouch | 1 | 0 | 7 | 0 | 0 | 16 | 0 | 0 | 0 |
| kneel up | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| crawl | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| off screen | 3 | 0 | 8 | 22 | 0 | 1 | 0 | 0 | 1341 |

| N0015 | Sit | lie | stand | walk | other | crouch | kneel up | Crawl | Off screen |
|---|---|---|---|---|---|---|---|---|---|
| Sit | 653 | 0 | 12 | 0 | 0 | 0 | 1 | 0 | 4 |
| Lie | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| stand | 4 | 0 | 1721 | 51 | 0 | 0 | 0 | 0 | 9 |
| walk | 8 | 1 | 36 | 543 | 0 | 2 | 0 | 0 | 18 |
| other | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| crouch | 2 | 0 | 1 | 0 | 0 | 110 | 0 | 0 | 2 |
| kneel up | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 0 | 0 |
| crawl | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| off screen | 3 | 0 | 13 | 13 | 0 | 3 | 0 | 0 | 354 |

| N0016 | Sit | lie | stand | walk | other | crouch | kneel up | crawl | Off screen |
|---|---|---|---|---|---|---|---|---|---|
| Sit | 942 | 0 | 9 | 0 | 1 | 0 | 3 | 0 | 7 |
| Lie | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| stand | 6 | 0 | 1664 | 57 | 0 | 0 | 1 | 0 | 5 |
| walk | 1 | 0 | 53 | 415 | 0 | 0 | 2 | 0 | 15 |
| other | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| crouch | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| kneel up | 5 | 0 | 1 | 0 | 0 | 0 | 11 | 0 | 0 |
| crawl | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| off screen | 7 | 0 | 6 | 14 | 0 | 0 | 0 | 0 | 331 |

| N0017 | Sit | lie | stand | walk | Other | crouch | kneel up | crawl | off screen |
|---|---|---|---|---|---|---|---|---|---|
| Sit | 2276 | 3 | 3 | 0 | 2 | 0 | 0 | 0 | 3 |
| lie | 0 | 537 | 0 | 0 | 4 | 0 | 2 | 1 | 0 |
| stand | 1 | 0 | 288 | 12 | 1 | 0 | 0 | 0 | 0 |
| walk | 5 | 0 | 7 | 143 | 0 | 0 | 0 | 0 | 3 |
| other | 1 | 4 | 3 | 0 | 56 | 0 | 1 | 1 | 0 |
| crouch | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| kneel up | 1 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 |
| crawl | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 6 | 0 |
| off screen | 3 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 297 |

| N0018 | Sit | lie | stand | walk | Other | crouch | kneel up | crawl | off screen |
|---|---|---|---|---|---|---|---|---|---|
| Sit | 2387 | 0 | 20 | 0 | 7 | 0 | 4 | 0 | 6 |
| lie | 0 | 3 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| stand | 15 | 0 | 538 | 28 | 1 | 2 | 0 | 0 | 0 |
| walk | 6 | 0 | 22 | 168 | 0 | 0 | 0 | 0 | 2 |
| other | 7 | 1 | 2 | 0 | 59 | 0 | 1 | 0 | 1 |
| crouch | 0 | 0 | 2 | 0 | 0 | 10 | 0 | 0 | 0 |
| kneel up | 3 | 0 | 0 | 0 | 2 | 0 | 39 | 0 | 0 |
| crawl | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| off screen | 7 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 277 |

| N0019 | Sit | lie | stand | walk | Other | crouch | kneel up | crawl | off screen |
|---|---|---|---|---|---|---|---|---|---|
| Sit | 2916 | 0 | 20 | 0 | 0 | 1 | 2 | 0 | 2 |
| lie | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| stand | 13 | 0 | 179 | 16 | 0 | 0 | 0 | 0 | 1 |
| walk | 7 | 0 | 9 | 100 | 0 | 0 | 0 | 0 | 4 |
| other | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| crouch | 1 | 0 | 0 | 0 | 0 | 13 | 0 | 0 | 0 |
| kneel up | 1 | 0 | 0 | 0 | 1 | 0 | 142 | 0 | 0 |
| crawl | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| off screen | 4 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 183 |

| N0020 | Sit | lie | stand | walk | Other | crouch | kneel up | crawl | off screen |
|---|---|---|---|---|---|---|---|---|---|
| Sit | 1342 | 4 | 10 | 0 | 7 | 0 | 2 | 1 | 0 |
| lie | 2 | 371 | 4 | 0 | 0 | 0 | 0 | 0 | 0 |
| stand | 7 | 0 | 1009 | 44 | 1 | 7 | 0 | 0 | 2 |
| walk | 6 | 0 | 26 | 511 | 1 | 9 | 1 | 0 | 3 |
| other | 5 | 0 | 3 | 1 | 77 | 0 | 2 | 0 | 1 |
| crouch | 1 | 0 | 14 | 0 | 1 | 21 | 0 | 0 | 0 |
| kneel up | 2 | 0 | 1 | 0 | 2 | 0 | 7 | 0 | 0 |
| crawl | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 14 | 0 |
| off screen | 1 | 1 | 3 | 1 | 0 | 0 | 0 | 0 | 89 |

| N0021 | Sit | lie | stand | Walk | Other | crouch | Kneel up | crawl | off screen |
|---|---|---|---|---|---|---|---|---|---|
| Sit | 874 | 0 | 16 | 4 | 2 | 0 | 0 | 0 | 11 |
| Lie | 0 | 4 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| Stand | 7 | 0 | 479 | 98 | 1 | 2 | 0 | 0 | 8 |
| walk | 17 | 2 | 77 | 1359 | 0 | 5 | 0 | 0 | 25 |
| Other | 2 | 0 | 1 | 0 | 7 | 0 | 0 | 0 | 0 |
| Crouch | 0 | 0 | 8 | 0 | 0 | 5 | 0 | 0 | 0 |
| kneel up | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Crawl | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| off screen | 7 | 0 | 12 | 24 | 0 | 1 | 0 | 0 | 501 |

| N0023 | Sit | lie | stand | walk | Other | crouch | Kneel up | crawl | Off screen |
|---|---|---|---|---|---|---|---|---|---|
| Sit | 1626 | 4 | 10 | 0 | 9 | 1 | 3 | 6 | 4 |
| lie | 4 | 121 | 3 | 0 | 7 | 1 | 0 | 2 | 0 |
| stand | 3 | 3 | 649 | 60 | 2 | 4 | 1 | 0 | 7 |
| walk | 6 | 3 | 48 | 345 | 1 | 2 | 0 | 0 | 3 |
| other | 9 | 5 | 7 | 0 | 232 | 0 | 1 | 1 | 0 |
| crouch | 2 | 0 | 4 | 1 | 1 | 22 | 0 | 1 | 0 |
| kneel up | 4 | 0 | 1 | 0 | 0 | 0 | 2 | 0 | 0 |
| crawl | 5 | 2 | 0 | 0 | 3 | 0 | 0 | 23 | 0 |
| off screen | 4 | 0 | 7 | 2 | 0 | 1 | 0 | 0 | 1774 |

| N0024 | Sit | lie | stand | walk | Other | crouch | kneel up | crawl | off screen |
|---|---|---|---|---|---|---|---|---|---|
| Sit | 1234 | 0 | 10 | 0 | 8 | 0 | 8 | 0 | 0 |
| lie | 1 | 7 | 0 | 0 | 1 | 0 | 1 | 0 | 0 |
| stand | 7 | 0 | 426 | 68 | 7 | 0 | 1 | 0 | 9 |
| walk | 4 | 1 | 53 | 868 | 8 | 1 | 0 | 0 | 23 |
| other | 9 | 1 | 14 | 2 | 122 | 0 | 3 | 0 | 0 |
| crouch | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| kneel up | 4 | 1 | 4 | 0 | 4 | 0 | 30 | 0 | 0 |
| crawl | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| off screen | 2 | 0 | 10 | 19 | 1 | 0 | 0 | 0 | 1333 |

| N0025 | Sit | lie | stand | walk | Other | crouch | kneel up | crawl | Off screen |
|---|---|---|---|---|---|---|---|---|---|
| Sit | 1580 | 1 | 9 | 0 | 1 | 0 | 3 | 5 | 3 |
| lie | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| stand | 5 | 0 | 1397 | 27 | 4 | 0 | 0 | 0 | 5 |
| walk | 5 | 0 | 23 | 183 | 2 | 0 | 0 | 0 | 4 |
| other | 1 | 0 | 4 | 2 | 52 | 0 | 0 | 0 | 1 |
| crouch | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| kneel up | 2 | 0 | 1 | 0 | 0 | 0 | 5 | 0 | 0 |
| crawl | 4 | 0 | 0 | 0 | 1 | 0 | 0 | 18 | 0 |
| off screen | 4 | 0 | 4 | 4 | 0 | 1 | 0 | 0 | 310 |

| N0027 | Sit | lie | stand | walk | other | crouch | kneel up | crawl | off screen |
|---|---|---|---|---|---|---|---|---|---|
| Sit | 885 | 0 | 11 | 1 | 2 | 0 | 0 | 2 | 6 |
| lie | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| stand | 11 | 0 | 1386 | 52 | 0 | 0 | 1 | 0 | 6 |
| walk | 2 | 0 | 52 | 364 | 0 | 0 | 1 | 0 | 6 |
| other | 2 | 0 | 1 | 0 | 3 | 0 | 0 | 0 | 0 |
| crouch | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| kneel up | 1 | 0 | 1 | 0 | 0 | 0 | 5 | 0 | 0 |
| crawl | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 12 | 0 |
| off screen | 5 | 0 | 4 | 8 | 0 | 0 | 0 | 0 | 1083 |

| N0028 | Sit | lie | stand | walk | other | crouch | kneel up | crawl | off screen |
|---|---|---|---|---|---|---|---|---|---|
| Sit | 1494 | 1 | 24 | 0 | 2 | 0 | 4 | 6 | 9 |
| lie | 1 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| stand | 21 | 0 | 1204 | 43 | 0 | 0 | 0 | 0 | 2 |
| walk | 6 | 0 | 34 | 327 | 0 | 0 | 0 | 0 | 7 |
| other | 2 | 0 | 0 | 0 | 24 | 0 | 1 | 1 | 0 |
| crouch | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| kneel up | 4 | 0 | 0 | 0 | 1 | 0 | 150 | 0 | 0 |
| Crawl | 7 | 0 | 1 | 0 | 1 | 0 | 0 | 34 | 0 |
| Off screen | 6 | 0 | 6 | 4 | 0 | 0 | 0 | 2 | 486 |

| N0029 | Sit | lie | stand | walk | other | crouch | kneel up | crawl | off screen |
|---|---|---|---|---|---|---|---|---|---|
| Sit | 629 | 0 | 20 | 3 | 3 | 1 | 0 | 0 | 11 |
| Lie | 0 | 5 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| Stand | 8 | 0 | 555 | 108 | 5 | 5 | 0 | 0 | 7 |
| Walk | 17 | 2 | 85 | 1560 | 1 | 8 | 0 | 0 | 26 |
| Other | 2 | 0 | 4 | 3 | 33 | 0 | 0 | 0 | 0 |
| crouch | 1 | 0 | 12 | 1 | 0 | 22 | 0 | 0 | 0 |
| kneel up | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Crawl | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Off screen | 10 | 0 | 9 | 24 | 0 | 0 | 0 | 0 | 369 |

| N0030 | Sit | lie | stand | walk | other | crouch | kneel up | crawl | off screen |
|---|---|---|---|---|---|---|---|---|---|
| Sit | 1853 | 1 | 11 | 0 | 0 | 0 | 0 | 1 | 1 |
| Lie | 0 | 6 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| Stand | 8 | 0 | 852 | 83 | 1 | 2 | 0 | 0 | 3 |
| Walk | 5 | 0 | 71 | 422 | 2 | 2 | 1 | 0 | 7 |
| Other | 0 | 1 | 3 | 0 | 22 | 0 | 0 | 0 | 0 |
| crouch | 0 | 0 | 2 | 1 | 1 | 3 | 0 | 0 | 0 |
| kneel up | 0 | 0 | 2 | 0 | 0 | 0 | 14 | 0 | 0 |
| Crawl | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 |
| Off screen | 0 | 0 | 7 | 4 | 0 | 0 | 0 | 0 | 331 |

| N0031 | Sit | lie | stand | walk | other | crouch | kneel up | crawl | off screen |
|---|---|---|---|---|---|---|---|---|---|
| **Sit** | 2292 | 0 | 15 | 0 | 2 | 0 | 3 | 1 | 0 |
| **lie** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **stand** | 11 | 0 | 980 | 25 | 3 | 1 | 0 | 0 | 0 |
| **walk** | 6 | 0 | 21 | 118 | 0 | 0 | 0 | 0 | 1 |
| **other** | 1 | 0 | 3 | 2 | 15 | 0 | 0 | 0 | 0 |
| **crouch** | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| **kneel up** | 3 | 0 | 0 | 0 | 0 | 0 | 45 | 0 | 0 |
| **crawl** | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 |
| **off screen** | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1813 |

| N0032 | Sit | lie | stand | walk | Other | crouch | kneel up | crawl | off screen |
|---|---|---|---|---|---|---|---|---|---|
| **Sit** | 354 | 0 | 4 | 0 | 1 | 0 | 6 | 0 | 0 |
| **Lie** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **stand** | 1 | 0 | 2312 | 154 | 0 | 1 | 0 | 0 | 6 |
| **walk** | 3 | 0 | 148 | 730 | 0 | 3 | 0 | 0 | 5 |
| **other** | 3 | 0 | 1 | 0 | 7 | 0 | 1 | 0 | 0 |
| **crouch** | 0 | 0 | 3 | 0 | 1 | 13 | 1 | 0 | 0 |
| **kneel up** | 4 | 0 | 0 | 0 | 3 | 1 | 52 | 0 | 0 |
| **crawl** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **off screen** | 0 | 0 | 5 | 5 | 0 | 0 | 0 | 0 | 150 |

## 5.6 Posture transitions: longest uninterrupted section

Data tables for all children are shown. Numbers in tables represent total seconds with the corresponding relationship between them. The number of posture transitions between categories is shown for direct observation, *activ*PAL$^{TM}$ and DynaPort MicroMod output.

### N0001

| Direct Observation | Sit | lie | stand | walk | other | crouch | kneel up | crawl | off screen |
|---|---|---|---|---|---|---|---|---|---|
| Sit | 1393 | 0 | 13 | 1 | 0 | 0 | 0 | 0 | 0 |
| Lie | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Stand | 13 | 0 | 240 | 7 | 0 | 0 | 0 | 0 | 0 |
| Walk | 2 | 0 | 6 | 45 | 0 | 0 | 0 | 0 | 0 |
| Other | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Crouch | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| kneel up | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Crawl | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| off screen | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 |

| *activ*PAL$^{TM}$ | sit/lie | stand | walk |
|---|---|---|---|
| sit/lie | 1028 | 30 | |
| Stand | 31 | 553 | 12 |
| Walk | | 12 | 54 |

| DynaPort | Sitting | Lying | Standing | Locomotion | Shuffling |
|---|---|---|---|---|---|
| Sitting | 540 | | 13 | | 2 |
| Lying | | | | | |
| Standing | 5 | | 904 | 7 | 60 |
| Locomotion | | | 7 | 44 | |
| Shuffling | 11 | | 51 | | 76 |

### N0002

| Direct Observation | Sit | lie | stand | walk | other | crouch | kneel up | crawl | off screen |
|---|---|---|---|---|---|---|---|---|---|
| Sit | 1410 | 0 | 44 | 1 | 0 | 0 | 0 | 0 | 0 |
| Lie | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Stand | 37 | 0 | 1237 | 38 | 0 | 5 | 0 | 0 | 0 |
| Walk | 9 | 0 | 30 | 173 | 0 | 0 | 0 | 0 | 0 |
| Other | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Crouch | 0 | 0 | 4 | 0 | 0 | 8 | 1 | 0 | 0 |
| kneel up | 0 | 0 | 1 | 0 | 0 | 0 | 11 | 0 | 0 |
| Crawl | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| off screen | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| *activ*PAL$^{TM}$ | sit/lie | stand | walk |
|---|---|---|---|
| sit/lie | 899 | 50 | |
| Stand | 51 | 1698 | 41 |
| Walk | | 41 | 233 |

| DynaPort | Sitting | Lying | Standing | Locomotion | Shuffling |
|---|---|---|---|---|---|
| Sitting | 858 | | 25 | | 2 |
| Lying | | | | | |
| Standing | 5 | | 1528 | 18 | 126 |
| Locomotion | | | 18 | 144 | |
| Shuffling | 22 | | 106 | | 157 |

## N0003

| Direct Observation | Sit | lie | stand | walk | other | crouch | kneel up | crawl | off screen |
|---|---|---|---|---|---|---|---|---|---|
| Sit | 1317 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 |
| Lie | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Stand | 5 | 0 | 1365 | 7 | 0 | 0 | 0 | 0 | 0 |
| Walk | 1 | 0 | 6 | 27 | 0 | 0 | 0 | 0 | 0 |
| Other | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Crouch | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| kneel up | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Crawl | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| off screen | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| *activ*PAL™ | sit/lie | stand | walk |
|---|---|---|---|
| sit/lie | 1317 | 6 | |
| Stand | 6 | 1353 | 7 |
| Walk | | 7 | 38 |

| DynaPort | Sitting | Lying | Standing | Locomotion | Shuffling |
|---|---|---|---|---|---|
| Sitting | 1916 | | 5 | | 4 |
| Lying | | | | | |
| Standing | 2 | | 599 | 6 | 44 |
| Locomotion | | | 6 | 37 | |
| Shuffling | 7 | | 41 | | 67 |

## N0004

| Direct Observation | Sit | lie | stand | walk | other | crouch | kneel up | crawl | off screen |
|---|---|---|---|---|---|---|---|---|---|
| Sit | 419 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| Lie | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Stand | 2 | 0 | 554 | 0 | 1 | 0 | 0 | 0 | 0 |
| Walk | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Other | 0 | 0 | 1 | 0 | 13 | 0 | 0 | 0 | 0 |
| Crouch | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| kneel up | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Crawl | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| off screen | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| *activ*PAL™ | sit/lie | Stand | walk |
|---|---|---|---|
| sit/lie | 423 | 5 | |
| Stand | 4 | 529 | 5 |
| Walk | | 4 | 22 |

| DynaPort | Sitting | Lying | Standing | Locomotion | Shuffling |
|---|---|---|---|---|---|
| Sitting | 197 | | | | 2 |
| Lying | | | | | |
| Standing | | | 731 | 2 | 15 |
| Locomotion | | | 1 | 3 | |
| Shuffling | 1 | | 16 | | 25 |

## N0005

| Direct Observe | Sit | lie | stand | walk | other | crouch | kneel up | crawl | off screen |
|---|---|---|---|---|---|---|---|---|---|
| Sit | 110 | 3 | 1 | 0 | 0 | 0 | 2 | 1 | 0 |
| Lie | 2 | 324 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| Stand | 0 | 0 | 149 | 9 | 0 | 0 | 0 | 0 | 0 |
| Walk | 2 | 0 | 5 | 61 | 1 | 0 | 1 | 0 | 0 |
| Other | 1 | 0 | 1 | 0 | 8 | 0 | 0 | 0 | 0 |
| Crouch | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| kneel up | 1 | 0 | 1 | 1 | 1 | 0 | 17 | 0 | 0 |
| Crawl | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| off screen | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| *activ*PAL™ | sit/lie | Stand | walk |
|---|---|---|---|
| sit/lie | 439 | 8 | |
| Stand | 7 | 123 | 14 |
| Walk | | 13 | 101 |

| DynaPort | Sitting | Lying | Standing | Locomotion | Shuffling |
|---|---|---|---|---|---|
| Sitting | 76 | 2 | 4 | | |
| Lying | 1 | 354 | 2 | | |
| Standing | 1 | | 89 | 5 | 28 |
| Locomotion | 1 | | 4 | 41 | |
| Shuffling | 3 | | 25 | | 69 |

## N0006

| Direct Observation | Sit | lie | stand | walk | other | crouch | kneel up | crawl | off screen |
|---|---|---|---|---|---|---|---|---|---|
| Sit | 417 | 11 | 2 | 0 | 0 | 0 | 2 | 0 | 0 |
| Lie | 11 | 155 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Stand | 0 | 0 | 29 | 4 | 1 | 1 | 1 | 0 | 0 |
| Walk | 0 | 0 | 3 | 16 | 0 | 2 | 0 | 0 | 0 |
| Other | 1 | 0 | 0 | 0 | 5 | 0 | 1 | 0 | 0 |
| Crouch | 0 | 0 | 3 | 0 | 0 | 8 | 0 | 0 | 0 |
| kneel up | 3 | 0 | 0 | 1 | 1 | 0 | 17 | 0 | 0 |
| Crawl | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| off screen | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| *activ*PAL™ | sit/lie | stand | walk |
|---|---|---|---|
| sit/lie | 605 | 8 | |
| Stand | 7 | 38 | 7 |
| Walk | | 7 | 24 |

| DynaPort | Sitting | Lying | Standing | Locomotion | Shuffling |
|---|---|---|---|---|---|
| Sitting | 62 | 2 | 6 | | |
| Lying | 1 | 259 | 2 | | |
| Standing | 3 | | 305 | 2 | 11 |
| Locomotion | | | 2 | 11 | |
| Shuffling | 4 | | 7 | | 18 |

## N0007

| Direct Observation | Sit | lie | stand | walk | other | crouch | kneel up | crawl | off screen |
|---|---|---|---|---|---|---|---|---|---|
| Sit | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Lie | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Stand | 0 | 0 | 2922 | 12 | 2 | 0 | 0 | 0 | 0 |
| Walk | 0 | 0 | 11 | 96 | 0 | 0 | 0 | 0 | 0 |
| Other | 0 | 0 | 2 | 0 | 14 | 0 | 0 | 0 | 0 |
| Crouch | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| kneel up | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Crawl | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| off screen | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total 3059 | | | | | | | | | |

| *activ*PAL™ | sit/lie | stand | walk |
|---|---|---|---|
| sit/lie | 4 | 1 | |
| Stand | 1 | 2817 | 29 |
| Walk | | 28 | 175 |

| DynaPort | Sitting | Lying | Standing | Locomotion | Shuffling |
|---|---|---|---|---|---|
| Sitting | 314 | | 30 | | 5 |
| Lying | | | | | |
| Standing | 13 | | 1721 | 15 | 228 |
| Locomotion | 1 | | 12 | 138 | 1 |
| Shuffling | 21 | | 213 | | 347 |

## N0008

| Direct Observation | Sit | lie | stand | walk | other | crouch | kneel up | crawl | off screen |
|---|---|---|---|---|---|---|---|---|---|
| Sit | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Lie | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Stand | 0 | 0 | 2833 | 7 | 1 | 3 | 0 | 0 | 0 |
| Walk | 0 | 0 | 7 | 33 | 0 | 0 | 0 | 0 | 0 |
| Other | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| Crouch | 0 | 0 | 3 | 0 | 0 | 5 | 0 | 0 | 0 |
| kneel up | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Crawl | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| off screen | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| *activ*PAL™ | sit/lie | stand | walk |
|---|---|---|---|
| sit/lie | 3 | 2 | |
| Stand | 2 | 2793 | 17 |
| Walk | | 17 | 57 |

| DynaPort | Sitting | Lying | Standing | Locomotion | Shuffling |
|---|---|---|---|---|---|
| Sitting | 211 | | 13 | | 1 |
| Lying | | | | | |
| Standing | 1 | | 1841 | 7 | 225 |
| Locomotion | | | 7 | 44 | |
| Shuffling | 13 | | 213 | | 318 |

## N0009

| Direct Observation | Sit | lie | stand | walk | other | Crouch | kneel up | crawl | off screen |
|---|---|---|---|---|---|---|---|---|---|
| Sit | 1090 | 0 | 0 | 0 | 4 | 1 | 0 | 2 | 0 |
| Lie | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Stand | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| Walk | 1 | 0 | 0 | 11 | 0 | 0 | 0 | 0 | 0 |
| Other | 3 | 0 | 0 | 0 | 27 | 0 | 0 | 1 | 0 |
| Crouch | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| kneel up | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Crawl | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 9 | 0 |
| off screen | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| *activ*PAL™ | sit/lie | stand | walk |
|---|---|---|---|
| sit/lie | 1126 | 4 | |
| Stand | 4 | 1 | 2 |
| Walk | | 3 | 13 |

| DynaPort | Sitting | Lying | Standing | Locomotion | Shuffling |
|---|---|---|---|---|---|
| Sitting | 393 | | 4 | | |
| Lying | | | | | |
| Standing | 2 | | 712 | 2 | 11 |
| Locomotion | | | 2 | 8 | |
| Shuffling | 2 | | 9 | | 10 |

## N0010

| Direct Observation | Sit | lie | stand | walk | other | crouch | kneel up | crawl | off screen |
|---|---|---|---|---|---|---|---|---|---|
| Sit | 248 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Lie | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Stand | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Walk | 1 | 0 | 0 | 22 | 0 | 0 | 0 | 0 | 0 |
| Other | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Crouch | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| kneel up | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Crawl | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| off screen | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| *activ*PAL™ | sit/lie | Stand | walk |
|---|---|---|---|
| sit/lie | 248 | | |
| Stand | 1 | | 1 |
| Walk | | 1 | 20 |

| DynaPort | Sitting | Lying | Standing | Locomotion | Shuffling |
|---|---|---|---|---|---|
| Sitting | 248 | | | | |
| Lying | | | | | |
| Standing | | | | | |
| Locomotion | 1 | | | 22 | |
| Shuffling | | | | | |

## N0011

| Direct Observation | Sit | lie | stand | walk | other | crouch | kneel up | crawl | off screen |
|---|---|---|---|---|---|---|---|---|---|
| **Sit** | 1179 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Lie** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Stand** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Walk** | 1 | 0 | 0 | 15 | 0 | 0 | 0 | 0 | 0 |
| **Other** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Crouch** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **kneel up** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Crawl** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **off screen** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| *activ*PAL™ | sit/lie | stand | walk |
|---|---|---|---|
| **sit/lie** | 1179 | | |
| **Stand** | 1 | 1 | 1 |
| **Walk** | | 1 | 12 |

| DynaPort | Sitting | Lying | Standing | Locomotion | Shuffling |
|---|---|---|---|---|---|
| **Sitting** | 1119 | | 3 | | |
| **Lying** | | | | | |
| **Standing** | | | 48 | | 4 |
| **Locomotion** | | | 1 | 13 | |
| **Shuffling** | 3 | | 1 | | 3 |

## N0012

| Direct Observation | Sit | lie | stand | walk | other | crouch | kneel up | crawl | off screen |
|---|---|---|---|---|---|---|---|---|---|
| **Sit** | 284 | 0 | 3 | 0 | 2 | 0 | 0 | 0 | 0 |
| **Lie** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Stand** | 2 | 0 | 742 | 14 | 2 | 4 | 0 | 0 | 0 |
| **Walk** | 1 | 0 | 11 | 82 | 1 | 1 | 0 | 0 | 0 |
| **Other** | 1 | 0 | 4 | 0 | 40 | 0 | 0 | 0 | 0 |
| **Crouch** | 0 | 0 | 5 | 0 | 0 | 7 | 0 | 0 | 0 |
| **kneel up** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Crawl** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **off screen** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| *activ*PAL™ | sit/lie | stand | walk |
|---|---|---|---|
| **sit/lie** | 290 | 11 | |
| **Stand** | 10 | 762 | 16 |
| **Walk** | | 16 | 96 |

| DynaPort | Sitting | Lying | Standing | Locomotion | Shuffling |
|---|---|---|---|---|---|
| **Sitting** | 105 | | 13 | | 2 |
| **Lying** | | | | | |
| **Standing** | 9 | | 610 | 13 | 94 |
| **Locomotion** | | | 13 | 84 | |
| **Shuffling** | 7 | | 89 | | 167 |

## N0013

| Direct Observation | Sit | lie | stand | walk | other | crouch | kneel up | crawl | off screen |
|---|---|---|---|---|---|---|---|---|---|
| Sit | 1533 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 0 |
| Lie | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Stand | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Walk | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Other | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Crouch | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| kneel up | 6 | 0 | 0 | 0 | 0 | 0 | 125 | 0 | 0 |
| Crawl | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| off screen | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| *activ*PAL™ | sit/lie | Stand | walk |
|---|---|---|---|
| sit/lie | 1400 | 4 | |
| Stand | 5 | 261 | |
| Walk | | | |

| DynaPort | Sitting | Lying | Standing | Locomotion | Shuffling |
|---|---|---|---|---|---|
| Sitting | 1599 | | 3 | | 1 |
| Lying | 1 | 13 | | | |
| Standing | 1 | 1 | 44 | | 2 |
| Locomotion | | | | | |
| Shuffling | 2 | | 1 | | 2 |

## N0014

| Direct Observation | Sit | lie | stand | walk | other | crouch | kneel up | crawl | off screen |
|---|---|---|---|---|---|---|---|---|---|
| Sit | 589 | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 0 |
| Lie | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Stand | 1 | 0 | 23 | 5 | 0 | 1 | 0 | 0 | 0 |
| Walk | 1 | 0 | 2 | 137 | 0 | 3 | 0 | 0 | 0 |
| Other | 1 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 |
| Crouch | 1 | 0 | 3 | 0 | 0 | 7 | 0 | 0 | 0 |
| kneel up | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Crawl | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| off screen | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| *activ*PAL™ | sit/lie | Stand | walk |
|---|---|---|---|
| sit/lie | 598 | 4 | |
| Stand | 5 | 37 | 5 |
| Walk | | 6 | 120 |

| DynaPort | Sitting | Lying | Standing | Locomotion | Shuffling |
|---|---|---|---|---|---|
| Sitting | 378 | | 7 | | |
| Lying | | | | | |
| Standing | 2 | | 195 | 7 | 15 |
| Locomotion | 1 | | 7 | 134 | |
| Shuffling | 5 | | 10 | | 18 |

## N0015

| Direct Observation | Sit | lie | stand | walk | other | crouch | kneel up | crawl | off screen |
|---|---|---|---|---|---|---|---|---|---|
| **Sit** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Lie** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Stand** | 0 | 0 | 520 | 4 | 0 | 0 | 0 | 0 | 0 |
| **Walk** | 0 | 0 | 3 | 50 | 0 | 0 | 0 | 0 | 0 |
| **Other** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Crouch** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **kneel up** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Crawl** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **off screen** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| ***activ*PAL™** | sit/lie | stand | walk |
|---|---|---|---|
| **sit/lie** | 1 | 1 | |
| **Stand** | 1 | 511 | 6 |
| **Walk** | | 5 | 52 |

| DynaPort | Sitting | Lying | Standing | Locomotion | Shuffling |
|---|---|---|---|---|---|
| **Sitting** | 31 | | 4 | | |
| **Lying** | | | | | |
| **Standing** | 2 | | 376 | 5 | 29 |
| **Locomotion** | | | 5 | 43 | |
| **Shuffling** | 2 | | 28 | | 52 |

## N0016

| Direct Observation | Sit | lie | stand | walk | other | crouch | kneel up | crawl | off screen |
|---|---|---|---|---|---|---|---|---|---|
| **Sit** | 326 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Lie** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Stand** | 0 | 0 | 296 | 9 | 0 | 0 | 0 | 0 | 0 |
| **Walk** | 0 | 0 | 9 | 51 | 0 | 0 | 0 | 0 | 0 |
| **Other** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Crouch** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **kneel up** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Crawl** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **off screen** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| ***activ*PAL™** | sit/lie | stand | walk |
|---|---|---|---|
| **sit/lie** | 1 | 1 | |
| **Stand** | 1 | 633 | 10 |
| **Walk** | | 10 | 35 |

| DynaPort | Sitting | Lying | Standing | Locomotion | Shuffling |
|---|---|---|---|---|---|
| **Sitting** | 328 | | 2 | | |
| **Lying** | | | | | |
| **Standing** | 1 | | 268 | 5 | 15 |
| **Locomotion** | | | 5 | 27 | |
| **Shuffling** | | | 15 | | 26 |

## N0017

| Direct Observation | Sit | lie | stand | walk | other | crouch | kneel up | crawl | off screen |
|---|---|---|---|---|---|---|---|---|---|
| Sit | 401 | 2 | 1 | 0 | 2 | 0 | 0 | 0 | 0 |
| Lie | 0 | 143 | 0 | 0 | 2 | 0 | 2 | 0 | 0 |
| Stand | 0 | 0 | 49 | 6 | 1 | 0 | 0 | 0 | 0 |
| Walk | 3 | 0 | 3 | 89 | 0 | 0 | 0 | 0 | 0 |
| Other | 1 | 2 | 3 | 0 | 46 | 0 | 1 | 0 | 0 |
| Crouch | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| kneel up | 1 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 |
| Crawl | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| off screen | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| *activ*PAL™ | sit/lie | stand | walk |
|---|---|---|---|
| sit/lie | 552 | 8 | |
| Stand | 8 | 111 | 6 |
| Walk | | 6 | 68 |

| DynaPort | Sitting | Lying | Standing | Locomotion | Shuffling |
|---|---|---|---|---|---|
| Sitting | 400 | 1 | 1 | | |
| Lying | | 45 | 1 | | |
| Standing | 1 | | 211 | 3 | 11 |
| Locomotion | | | 3 | 58 | |
| Shuffling | 1 | | 10 | | 14 |

## N0018

| Direct Observation | Sit | lie | stand | walk | other | crouch | kneel up | crawl | off screen |
|---|---|---|---|---|---|---|---|---|---|
| Sit | 706 | 0 | 14 | 0 | 0 | 0 | 0 | 0 | 0 |
| Lie | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Stand | 13 | 0 | 416 | 17 | 0 | 2 | 0 | 0 | 0 |
| Walk | 1 | 0 | 16 | 105 | 0 | 0 | 0 | 0 | 0 |
| Other | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Crouch | 0 | 0 | 2 | 0 | 0 | 10 | 0 | 0 | 0 |
| kneel up | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Crawl | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| off screen | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| *activ*PAL™ | sit/lie | stand | walk |
|---|---|---|---|
| sit/lie | 264 | 28 | |
| Stand | 27 | 821 | 20 |
| Walk | | 20 | 119 |

| DynaPort | Sitting | Lying | Standing | Locomotion | Shuffling |
|---|---|---|---|---|---|
| Sitting | 201 | | 6 | | 3 |
| Lying | | | | | |
| Standing | 5 | | 857 | 9 | 42 |
| Locomotion | | | 9 | 48 | |
| Shuffling | 4 | | 41 | | 77 |

# N0019

| Direct Observation | Sit | lie | stand | walk | other | crouch | kneel up | crawl | off screen |
|---|---|---|---|---|---|---|---|---|---|
| Sit | 1389 | 0 | 8 | 0 | 0 | 0 | 0 | 0 | 0 |
| Lie | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Stand | 8 | 0 | 67 | 0 | 0 | 0 | 0 | 0 | 0 |
| Walk | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Other | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Crouch | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| kneel up | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Crawl | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| off screen | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| *activ*PAL™ | sit/lie | stand | walk |
|---|---|---|---|
| sit/lie | 1370 | 5 | |
| Stand | 5 | 92 | |
| Walk | | | |

| DynaPort | Sitting | Lying | Standing | Locomotion | Shuffling |
|---|---|---|---|---|---|
| Sitting | 343 | | 9 | | |
| Lying | | | | | |
| Standing | 6 | | 1050 | 1 | 20 |
| Locomotion | | | 1 | 2 | |
| Shuffling | 3 | | 17 | | 20 |

# N0020

| Direct Observation | Sit | lie | stand | walk | other | crouch | kneel up | crawl | off screen |
|---|---|---|---|---|---|---|---|---|---|
| Sit | 275 | 1 | 1 | 0 | 2 | 0 | 0 | 0 | 0 |
| Lie | 1 | 70 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Stand | 2 | 0 | 524 | 13 | 1 | 0 | 0 | 0 | 0 |
| Walk | 1 | 0 | 10 | 220 | 1 | 2 | 0 | 0 | 0 |
| Other | 1 | 0 | 2 | 1 | 20 | 0 | 0 | 0 | 0 |
| Crouch | 0 | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 0 |
| kneel up | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Crawl | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| off screen | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| *activ*PAL™ | sit/lie | stand | walk |
|---|---|---|---|
| sit/lie | 351 | 5 | |
| Stand | 6 | 551 | 20 |
| Walk | | 20 | 197 |

| DynaPort | Sitting | Lying | Standing | Locomotion | Shuffling |
|---|---|---|---|---|---|
| Sitting | 156 | 1 | 1 | | |
| Lying | | 73 | 1 | | |
| Standing | 2 | | 492 | 17 | 39 |
| Locomotion | | | 18 | 236 | |
| Shuffling | 1 | | 38 | | 76 |

## N0021

| Direct Observation | Sit | lie | stand | walk | other | crouch | kneel up | crawl | off screen |
|---|---|---|---|---|---|---|---|---|---|
| Sit | 237 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| Lie | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Stand | 0 | 0 | 48 | 8 | 0 | 1 | 0 | 0 | 0 |
| Walk | 2 | 0 | 7 | 38 | 0 | 0 | 0 | 0 | 0 |
| Other | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Crouch | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| kneel up | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Crawl | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| off screen | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| *activ*PAL™ | sit/lie | Stand | walk |
|---|---|---|---|
| sit/lie | 216 | 2 | |
| Stand | 3 | 51 | 6 |
| Walk | | 6 | 57 |

| DynaPort | Sitting | Lying | Standing | Locomotion | Shuffling |
|---|---|---|---|---|---|
| Sitting | 89 | | 2 | | |
| Lying | | | | | |
| Standing | | | 130 | 6 | 15 |
| Locomotion | | | 6 | 42 | |
| Shuffling | 3 | | 12 | | 38 |

## N0023

| Direct Observation | Sit | lie | stand | walk | other | crouch | kneel up | crawl | off screen |
|---|---|---|---|---|---|---|---|---|---|
| Sit | 308 | 3 | 1 | 0 | 5 | 0 | 2 | 5 | 0 |
| Lie | 4 | 76 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| Stand | 0 | 0 | 138 | 11 | 0 | 0 | 1 | 0 | 0 |
| Walk | 0 | 0 | 9 | 54 | 1 | 0 | 0 | 0 | 0 |
| Other | 5 | 1 | 0 | 0 | 189 | 0 | 1 | 1 | 0 |
| Crouch | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| kneel up | 3 | 0 | 1 | 0 | 0 | 0 | 2 | 0 | 0 |
| Crawl | 4 | 2 | 0 | 0 | 1 | 0 | 0 | 2 | 0 |
| off screen | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| *activ*PAL™ | sit/lie | stand | walk |
|---|---|---|---|
| sit/lie | 477 | 14 | |
| Stand | 14 | 251 | 9 |
| Walk | | 9 | 59 |

| DynaPort | Sitting | Lying | Standing | Locomotion | Shuffling |
|---|---|---|---|---|---|
| Sitting | 80 | 1 | 6 | | |
| Lying | 1 | 142 | 4 | 1 | |
| Standing | 4 | 5 | 460 | 3 | 14 |
| Locomotion | | | 4 | 59 | |
| Shuffling | 2 | | 12 | | 34 |

## N0024

| Direct Observation | Sit | lie | stand | walk | other | crouch | kneel up | crawl | off screen |
|---|---|---|---|---|---|---|---|---|---|
| Sit | 837 | 0 | 2 | 0 | 1 | 0 | 6 | 0 | 0 |
| Lie | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Stand | 0 | 0 | 53 | 5 | 0 | 0 | 1 | 0 | 0 |
| Walk | 3 | 0 | 2 | 52 | 0 | 0 | 0 | 0 | 0 |
| Other | 2 | 0 | 1 | 0 | 23 | 0 | 2 | 0 | 0 |
| Crouch | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| kneel up | 3 | 0 | 2 | 0 | 4 | 0 | 21 | 0 | 0 |
| Crawl | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| off screen | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| *activ*PAL™ | sit/lie | stand | walk |
|---|---|---|---|
| sit/lie | 791 | 6 | |
| Stand | 5 | 145 | 6 |
| Walk | | 6 | 60 |

| DynaPort | Sitting | Lying | Standing | Locomotion | Shuffling |
|---|---|---|---|---|---|
| Sitting | 728 | | 7 | | 1 |
| Lying | | | | | |
| Standing | 7 | | 128 | 6 | 21 |
| Locomotion | | | 6 | 47 | |
| Shuffling | | | 22 | | 47 |

## N0025

| Direct Observation | Sit | lie | stand | walk | other | crouch | kneel up | crawl | off screen |
|---|---|---|---|---|---|---|---|---|---|
| Sit | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Lie | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Stand | 0 | 0 | 1021 | 4 | 1 | 0 | 0 | 0 | 0 |
| Walk | 0 | 0 | 4 | 10 | 0 | 0 | 0 | 0 | 0 |
| Other | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| Crouch | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| kneel up | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Crawl | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| off screen | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| *activ*PAL™ | sit/lie | stand | walk |
|---|---|---|---|
| sit/lie | | | |
| Stand | | 1032 | 3 |
| Walk | | 3 | 4 |

| DynaPort | Sitting | Lying | Standing | Locomotion | Shuffling |
|---|---|---|---|---|---|
| Sitting | 236 | | | | 2 |
| Lying | | | | | |
| Standing | 1 | | 743 | 1 | 14 |
| Locomotion | | | 1 | 5 | |
| Shuffling | 1 | | 16 | | 22 |

# N0027

| Direct Observation | Sit | lie | stand | walk | other | crouch | kneel up | crawl | off screen |
|---|---|---|---|---|---|---|---|---|---|
| Sit | 528 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| Lie | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Stand | 1 | 0 | 54 | 2 | 0 | 0 | 0 | 0 | 0 |
| Walk | 0 | 0 | 3 | 25 | 0 | 0 | 0 | 0 | 0 |
| Other | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Crouch | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| kneel up | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Crawl | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 |
| off screen | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| *activ*PAL™ | sit/lie | stand | walk |
|---|---|---|---|
| sit/lie | 507 | 1 | |
| Stand | 1 | 84 | 4 |
| Walk | | 4 | 18 |

| DynaPort | Sitting | Lying | Standing | Locomotion | Shuffling |
|---|---|---|---|---|---|
| Sitting | 509 | | 1 | | |
| Lying | | | | | |
| Standing | 2 | | 79 | 2 | 1 |
| Locomotion | | | 3 | 19 | |
| Shuffling | | | 1 | | 2 |

# N0028

| Direct Observation | Sit | lie | stand | walk | other | crouch | kneel up | crawl | off screen |
|---|---|---|---|---|---|---|---|---|---|
| Sit | 436 | 0 | 2 | 0 | 2 | 0 | 4 | 3 | 0 |
| Lie | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Stand | 1 | 0 | 89 | 13 | 0 | 0 | 0 | 0 | 0 |
| Walk | 1 | 0 | 11 | 84 | 0 | 0 | 0 | 0 | 0 |
| Other | 2 | 0 | 0 | 0 | 20 | 0 | 1 | 0 | 0 |
| Crouch | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| kneel up | 4 | 0 | 0 | 0 | 1 | 0 | 150 | 0 | 0 |
| Crawl | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 16 | 0 |
| off screen | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| *activ*PAL™ | sit/lie | stand | walk |
|---|---|---|---|
| sit/lie | 410 | 11 | |
| Stand | 10 | 241 | 10 |
| Walk | | 10 | 148 |

| DynaPort | Sitting | Lying | Standing | Locomotion | Shuffling |
|---|---|---|---|---|---|
| Sitting | 449 | 1 | 8 | | |
| Lying | | 6 | 1 | | |
| Standing | 5 | | 192 | 7 | 20 |
| Locomotion | 1 | | 6 | 92 | |
| Shuffling | 3 | | 16 | | 36 |

# N0029

| Direct Observation | Sit | lie | stand | walk | other | crouch | kneel up | crawl | off screen |
|---|---|---|---|---|---|---|---|---|---|
| Sit | 61 | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 0 |
| Lie | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Stand | 1 | 0 | 79 | 12 | 0 | 0 | 0 | 0 | 0 |
| Walk | 1 | 0 | 11 | 201 | 0 | 0 | 0 | 0 | 0 |
| Other | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Crouch | 1 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 |
| kneel up | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Crawl | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| off screen | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| *activ*PAL™ | sit/lie | stand | walk |
|---|---|---|---|
| sit/lie | 55 | 2 | |
| Stand | 2 | 95 | 9 |
| Walk | | 10 | 197 |

| DynaPort | Sitting | Lying | Standing | Locomotion | Shuffling |
|---|---|---|---|---|---|
| Sitting | 6 | | 3 | | |
| Lying | | | | | |
| Standing | 2 | | 95 | 12 | 10 |
| Locomotion | 1 | | 10 | 205 | |
| Shuffling | | | 10 | | 19 |

# N0030

| Direct Observation | Sit | lie | stand | walk | other | crouch | kneel up | crawl | off screen |
|---|---|---|---|---|---|---|---|---|---|
| Sit | 1268 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| Lie | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Stand | 1 | 0 | 15 | 4 | 0 | 0 | 0 | 0 | 0 |
| Walk | 1 | 0 | 3 | 50 | 0 | 0 | 0 | 0 | 0 |
| Other | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Crouch | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| kneel up | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Crawl | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| off screen | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| *activ*PAL™ | sit/lie | stand | walk |
|---|---|---|---|
| sit/lie | 1188 | 6 | |
| Stand | 6 | 92 | 2 |
| Walk | | 2 | 47 |

| DynaPort | Sitting | Lying | Standing | Locomotion | Shuffling |
|---|---|---|---|---|---|
| Sitting | 929 | | 4 | | 1 |
| Lying | | | | | |
| Standing | 3 | | 282 | 4 | 24 |
| Locomotion | | | 5 | 35 | |
| Shuffling | 2 | | 22 | | 33 |

# N0031

| Direct Observation | Sit | lie | stand | Walk | other | crouch | kneel up | crawl | off screen |
|---|---|---|---|---|---|---|---|---|---|
| Sit | 1681 | 0 | 11 | 0 | 1 | 0 | 1 | 1 | 0 |
| Lie | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Stand | 10 | 0 | 34 | 3 | 0 | 0 | 0 | 0 | 0 |
| Walk | 2 | 0 | 2 | 31 | 0 | 0 | 0 | 0 | 0 |
| Other | 1 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 |
| Crouch | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| kneel up | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 |
| Crawl | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 |
| off screen | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| *activ*PAL™ | sit/lie | stand | walk |
|---|---|---|---|
| sit/lie | 962 | 46 | |
| Stand | 47 | 668 | 10 |
| Walk | | 11 | 43 |

| DynaPort | Sitting | Lying | Standing | Locomotion | Shuffling |
|---|---|---|---|---|---|
| Sitting | 1127 | 1 | 13 | | 5 |
| Lying | | 13 | 1 | | |
| Standing | 10 | | 431 | 3 | 38 |
| Locomotion | | | 4 | 28 | |
| Shuffling | 10 | | 33 | | 69 |

# N0032

| Direct Observation | Sit | lie | stand | walk | other | crouch | kneel up | crawl | off screen |
|---|---|---|---|---|---|---|---|---|---|
| Sit | 43 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Lie | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Stand | 0 | 0 | 994 | 70 | 0 | 1 | 0 | 0 | 0 |
| Walk | 1 | 0 | 70 | 384 | 0 | 0 | 0 | 0 | 0 |
| Other | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Crouch | 0 | 0 | 1 | 0 | 0 | 7 | 0 | 0 | 0 |
| kneel up | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Crawl | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| off screen | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| *activ*PAL™ | sit/lie | stand | walk |
|---|---|---|---|
| sit/lie | 8 | 2 | |
| Stand | 2 | 1118 | 46 |
| Walk | | 47 | 342 |

| DynaPort | Sitting | Lying | Standing | Locomotion | Shuffling |
|---|---|---|---|---|---|
| Sitting | 18 | | 2 | | |
| Lying | | | | | |
| Standing | 1 | | 678 | 35 | 115 |
| Locomotion | | | 34 | 327 | 2 |
| Shuffling | 1 | | 116 | | 243 |

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