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Validity testing of self-report questionnaires on physical activity for people with spinal cord injury

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Fysisk aktivitet för personer med ryggmärgsskada. Validitetstestning av frågeformulär.

Abstrakt

Bakgrund

Fysisk aktivitet (FA) har hälsorelaterade effekter medan fysisk inaktivitet är relaterat till ökad risk för hjärt-och kärlsjukdom. Personer med ryggmärgsskada har en lägre fysisk aktivitetsnivå och högre förekomst av kardiovaskulär ohälsa jämfört med normalpopulationen. För att identifiera grupper och individer i behov av FA intervention behövs valida metoder, tex frågeformulär om FA. För närvarande finns dock inte något sådant om FA som också är validerat eller används för personer med ryggmärgsskada.

Syfte

Syftet med studien var att beskriva kriterievaliditeten i två frågeformulär om FA mot accelerometerdata samt att undersöka om det fanns skillnad i validitet mellan ett mycket kort frågeformulär jämfört med ett längre.

Metod

Tvärsnittsstudie för att bedöma kriterievaliditeten i Frågeformulär om Fysisk Aktivitet efter Ryggmärgsskada (F-FAR) och Socialstyrelsens indikatorfrågor om fysisk aktivitet mot objektiv data från accelerometrar.

Resultat

18 deltagare med motorkomplett paraplegi inkluderades, varav 13 var män. Medelålder 47±14,5 år, vikt 74±14,2 kg, år sedan skada varierade mellan 2–46. Det fanns en statistiskt signifikant korrelation mellan F-FAR och accelerometerdata ($r=0{,}574$, $p=0{,}013$). Det fanns också en moderat korrelation mellan Socialstyrelsens indikatorfrågor om fysisk aktivitet och accelerometerdata, dock inte signifikant ($r=0{,}337$, $p=0{,}186$).

Sammanfattning

Resultatet antyder att F-FAR kan användas som utvärderingsinstrument för att bedöma fysisk aktivitet hos personer med ryggmärgsskada. Den icke signifikanta korrelationen med Socialstyrelsens indikatorfrågor om FA tyder på att ett ryggmärgsskadespecifikt frågeformulär är en mer lämplig metod.

Nyckelord

Accelerometer, kriterievalididet, samtidig validitet, psykometriska egenskaper, paraplegi

Abstract

Background

Engaging in physical activity (PA) has health related benefits whilst physical inactivity is correlated to increased risk for cardiovascular disease. The population with spinal cord injury (SCI) is more sedentary than general population and also has a higher prevalence of cardiovascular disease. Identifying groups and individuals in need of interventions concerning PA demands valid methods as for example questionnaires on PA. At present there is no self-report questionnaire on PA that is validated on or used in clinical setting for the SCI-population

Aim

The aim of this study was to describe the criterion validity of two self-report questionnaires compared with accelerometer data and investigate if there was any difference in validity between a longer self-report questionnaire compared with a brief.

Method

Cross-sectional study for assessing the criterion validity of Frågeformulär om Fysisk Aktivitet efter Ryggmärgsskada (F-FAR) and the Swedish National Board of Health and Welfare physical activity questions (BHW PA questions) compared with objective data from accelerometers.

Results

18 participants with motor-complete paraplegia were included in the study, 13 men. Mean age 47±14.5 years, weight 74±14.2 kg, years since injury ranged from 2-46. It was found a statistically significant correlation between the F-FAR and accelerometer data ($r=0.574$, $p=0.013$). There was also a moderate correlation between the BHW PA questions and accelerometer data but not statistically significant ($r=0.337$, $p=0.186$).

Conclusion

The study suggests that F-FAR is a promising method to capture PA level in persons with SCI. The non-significant correlation to the shorter self-report BHW PA questions indicates that a SCI-specific questionnaire is a more appropriate method.

Keywords

Accelerometer, criterion validity, concurrent validity, psychometric property, paraplegia

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Introduction

In my work as a physical therapist within the neurological field I have taken a special interest in physical activity (PA) as a way of maintaining and improving health. This can be challenging enough for the able-bodied population but even more so for people with physical disabilities. Proper assessment of PA levels is of importance for different reasons. For example, it can be useful for assessing current level of PA or when deciding on actions with the aim of increasing levels of PA. At present there is no gold standard questionnaire on PA for persons with spinal cord injuries used in the clinical setting.

1 Background

1.1 Spinal cord injuries

The spinal cord is part of the central nervous system and is located within the spinal column. It descends from the skull down to the lumbar part of the column with the function to send signals back and forth to the brain. The spinal column consists of vertebrae divided into cervical, thoracic and lumbar regions and the spinal cord is categorised in the same manner(1). When a spinal cord injury(SCI) occurs it leads to loss of nerve transmission that affects motor pathways, sensory pathways, autonomic functions etc.(1). A SCI can be either traumatic or non-traumatic. The incidence of traumatic SCI in Sweden is 19 per million, 60% men(2). The total incidence including non-traumatic SCI is not known but a rough estimate is that the non-traumatic number is fairly similar to the traumatic SCI(3). The most common causes for traumatic SCI in Sweden are falls (58%) and traffic related accidents (40%)(2). Origins of a non-traumatic SCI can be of various causes as for example infections, tumours and circulation disorders(1). Injuries located at the cervical part of the spinal cord result in a tetraplegia and affect arms, trunk and legs. Injuries located at the level of the first thoracic vertebrae or below result in paraplegia which affect trunk and legs(1). In addition to level of injury all SCI’s are classified according to the American Spinal Injury Association Impairment Scale A-E (AIS). In brief an injury of AIS A means complete loss of both motor control and sensory functions below the level of injury including absent function in the lowest sacral segment. An AIS B is defined as total loss of motor control but with some sensory function preserved below the level of injury. Injuries AIS C and D are defined by both preserved motor and sensory function below the level of injury but of different magnitude. AIS E means that a person has regained all motor and sensory function after a SCI (4). A person with a SCI of AIS A or B, that has no motor control below the level of injury, is dependent on a wheelchair for transportation. A person with a motor-complete paraplegia, in general use a manual wheelchair i.e. propelled by own arm muscle force, whereas a person with a high level of tetraplegia might use a powered wheelchair since the muscle control in arms and hands is affected. Persons with lower levels of injury, within the sacral area, might be able to walk with aids as for example a walker or crutches.

A SCI permanently changes many aspects in a person's life. Activities and participation like independence in daily life, walking, transfers and body functions as voluntary bladder control, sexual functions, presence of pain and spasticity are some examples. Still there is no cure for SCI and rehabilitation and lifelong follow up are therefore focused on compensatory strategies for consequences after SCI as well as on preventing secondary complications. PA is one of many domains that need special attention and adaptation after a SCI.

1.2 Physical activity

1.2.1 Physical activity and energy expenditure - definitions

PA is defined as "any bodily movement produced by skeletal muscles that results in energy expenditure"(5). By the abovementioned definition of PA all activities in daily living are addressed as PA, for example household chores, transportation to work/studies, sports etc. Exercise is as subset of PA where the activities are planned and structured with the intent of improving or maintaining physical fitness(5). Non-exercise PA, are activities that is performed in daily living without the intent of being exercise and are often of low intensities(6). Leisure time PA is defined as activities performed during free time and can be of various intensities. Energy expenditure is a measure of three components where PA energy expenditure is one part. The other two are energy needed for basal metabolic rate and energy used for thermic effect of food(7). To increase energy expenditure the amount of PA needs to be increased. For an able-bodied but sedentary person the basal metabolic rate stands for ca 60% of total energy expenditure(7).

The SCI-population has a lower energy expenditure both in rest and during activities compared to the able-bodied population due to the loss of muscle mass after paralysis (8-10). One study has reported a resting energy expenditure with a mean of 2.47 ml $O_2 \cdot kg^{-1} \cdot min^{-1}$ for a group of paraplegic men and women. This is in comparison ca 30% less than the general population(10).

1.2.2 Recommendations for physical activity

The general PA recommendations from World Health Organization (WHO), for reducing risk for cardiovascular disease and other conditions are: at least 150 minutes/week of moderate intensity PA or 75 minutes/week of exercise in a vigorous mode. Weight training, that engages larger muscle groups, is recommended 2 times/week(11). In addition, there is a recommendation of avoiding prolonged periods of sedentary time. These recommendations are adopted in Sweden as national guidelines(12).

There are no specific recommendations concerning dose or mode of PA for the SCI-population in Sweden for reducing risk for cardiovascular disease. Therefore, Swedish health care professionals are referred to the general guidelines. The general guidelines for PA and exercise have been questioned for the SCI-population. Apart from the obvious challenge the physical impairment poses there are other issues to consider when planning and performing PA and exercise. For example, there is an increased risk for over-use injuries in the upper body, skin lesions and over-heating during exercise(13). With this as a standpoint, Ginis et al developed specific guidelines for the SCI-population with the aim to improve cardio metabolic health. The recommendations are: 20 minutes/2 times per week of at least moderate to vigorous aerobic exercise and 3 sets of strength exercises (of major functioning muscle groups) 2 times per week(13). The SCI-specific guidelines have been questioned as they are deemed to not be sufficient for improving vascular health(14). The SCI-specific guidelines are translated into Swedish and available online(15). They are however not integrated in the recommendations from Fysisk Aktivitet och Sjukdomsprevention (FYSS) nor established practice within the Swedish healthcare.

1.2.3 Physical inactivity

Physical inactivity would be defined as not reaching the recommended levels of PA. According to WHO, physical inactivity is now the fourth leading cause of mortality worldwide(11). Apart from the personal suffering physical inactivity also contributes to a big economic burden. In a rapport from the Public Health Agency of Sweden (Folkhälsomyndigheten) from 2010 it is stated that diseases related to physical inactivity account for costs about seven trillions Swedish Crowns each year in Sweden(16). Sedentary behaviour has been acknowledged as a separate risk factor for developing disease. That is, even if a person is physically active in terms of exercising regularly, there is risk for disease due to an otherwise sedentary lifestyle(17). The increasing volumes of sedentary time has mainly replaced light non-exercise physical activities(18).

The SCI-population have in general a lower level of PA compared with the able-bodied population. A Canadian study found that 88% did not reach the levels recommended in SCI-specific guidelines for PA(19). The population with motor-complete SCI are more sedentary than general population. The increased time of sedentary activities may contribute to an increased risk for health-related disease, although this correlation is not yet fully established. It is however confirmed that people with SCI have a high prevalence and increased risk for cardiovascular disease (diabetes mellitus type 2, dyslipedemiae, hypertension) compared with the able-bodied population(20).

1.2.4 Health benefits related to physical activity

There is evidence for the positive relation between PA and health, i.e. regular physical exercise is strongly related to reduced risk for cardiovascular disease (CVD), diabetes mellitus type 2 (DM2), hypertension, different forms of cancer and premature mortality (21). A general active lifestyle, that is a high level of non-exercise PA, has been shown to correlate with decreased risk of cardiovascular disease regardless of structured exercise or not(6).
The recommendations for PA are defined as minimum levels of activity for avoiding health risks related to inactivity. However, there is a dose-response relationship where one can expect additional benefits if the time of PA exceeds the recommendations(22). Also, even if the recommendations are not fully met there are still health related benefits to gain if an inactive person becomes slightly more active(21, 23). Cardiovascular factors are mainly influenced by aerobic exercise while weight training also reduces the risk for osteoporosis(24). Non-exercise PA has been found to have a great impact on energy expenditure and also resistance to fat gain(7).

There is evidence that physical exercise has positive effects for the SCI-population, as for example improved cardiorespiratory fitness and muscle strength (25-27). It is not clearly shown to which degree PA effects cardiovascular markers for the SCI-population. There is however indication that there is a positive relationship between PA and lower diastolic blood pressure(28). One study also found lower levels of proteins related to vascular disease in physically active persons with SCI compared to a group of sedentary SCI(29). Non-exercise physical activities may be an important factor for persons with SCI when aiming at increasing PA and energy expenditure(9, 10).

1.3 Intensities of physical activity

The most commonly used terms for describing levels of PA intensity is light, moderate and vigorous(24).
Absolute intensity is related to the physical workload, i.e. the energy expended when performing activities (in ml $O_2 \cdot kg^{-1} \cdot min^{-1}$ or kcal/minute). There are different measures of absolute intensity as for example Metabolic Equivalent of Task (MET), peak oxygen uptake (VO_2 peak), watt, kcal/minute etc.(24). MET is the most commonly used absolute measure for defining intensity levels. MET is calculated from the energy expenditure derived during sitting quietly called the resting metabolic rate or resting energy expenditure. It is referred to as 1 MET- value and corresponds to 3.5 ml $O_2 \cdot kg^{-1} \cdot min^{-1}$(30), which is multiplied to create the MET-values i.e. 3MET= 10.5 ml $O_2 \cdot kg^{-1} \cdot min^{-1}$. There are standardized intensity levels for different activities based on MET-values for the able-bodied population (30). Intensity of 3-6 METs is classified as moderate and >6 METs as vigorous(24). Standardized MET-values don’t take into account differences in body mass index, amount of fat mass and fat free mass and other

variables that has been shown to influence energy expenditure(31). Hence, there is a great risk of miscalculation if using MET-values as reference (31). Byrne et al suggests adjusted MET-levels, if to be used, as calculation of energy expenditure related to moderate intensity(31). Another measure of absolute intensity, often referred to, is VO_2 peak. This measure is determined by when oxygen consumption reaches a plateau during maximal physical effort (24). Since an absolute intensity is related to the workload and not to the one performing the task, an absolute intensity i.e. for example 3 METs will be perceived very differently depending on age, sex, level of fitness etc. A brisk walk can for someone feel like an activity of light intensity while for another as vigorous exercise(24). The different experiences of an absolute intensity is one reason to instead use a relative intensity approach, which is recommended for groups such as the geriatric population or other populations of low physical capacity as for example the SCI-population(24).

Relative intensity is described as a relation to an individual maximal or peak capacity. Relative intensity is not only influenced by physical capacity, it is also influenced by age, gender, amount of fat mass etc. There are several measures of relative intensity as for example percentage of peak oxygen uptake (%VO_2 peak), percentage of heart rate reserve etc.(24). When using %VO_2 peak as an estimate for relative intensity (able-bodied population) moderate and vigorous levels would conform to 46-63% and 64-90% of VO_2 peak respectively (24). The term relative intensity is not to be mistaken for perceived intensity as it still is calculated in relation to a person's absolute capacity. In a clinical setting intensity can be determined by using instruments for rating perceived exertion, for example Borg Rating of Perceived Exertion Scale 6-20 (Borg RPE 6-20). Rating an activity as fairly light to somewhat hard (RPE 12-13) on 6-20 Borg RPE correlates fairly well to moderate intensity and somewhat hard to very hard (RPE 14-17) to vigorous intensity (24).

For different subgroups, as for example the SCI-population where the amount of muscle mass is markedly decreased due to paralysis, MET-values should be questioned even more for estimating intensity and energy expenditure(24). Due to paralysis VO_2 peak is lower than in general population and reaching the level of 6 standard METs might even be above VO_2 peak and therefore not a useful tool. There are however suggested MET-values for subgroups within the SCI-population. A few studies have reported similar results but there is not yet a consensus on 1 MET-value for the SCI-population(8-10). Even if the SCI-METs are to be used there is no direct correlation between the original MET and the adjusted SCI-MET. No conclusion on health effects can be made from performing exercise with an intensity of 3 SCI-METs. Therefore, it would not be appropriate to define for example 3 SCI-MET as threshold for moderate intensity as the original MET is used. Ginis et al developed a SCI-specific self-classification system for intensity with three different levels; mild, moderate and heavy(32). The rationale for implementing this new set of self-perceived intensity levels was that other instruments were deemed not suitable for the SCI-population according to the authors. A SCI of T6 or above leads to disrupted sympathetic innervation of the heart and therefore physiological responses to physical exertion will not be equal as for the able-bodied population. Thus making it harder to use generic intensity levels which are often based on level of sweating, heart rate etc.(32). The SCI-specific levels of intensity were developed by using the VO_2 peak and Borg RPE. A percentage of individual VO_2 reserve was used to correlate to different levels of intensity, moderate intensity to 40-59% of VO_2 reserve and >60%of VO_2 reserve as heavy. The abovementioned study had a study sample of 11 participants including both persons with tetra- and paraplegia(32). These SCI-specific intensity levels are not widely used.

1.4 Assessment of physical activity

When assessing PA in clinical practice self-report by questionnaires are the most used method. Other forms of self-report can be interviews and activity diaries. More objective ways of measuring PA is for example the use of accelerometers, doubly labelled water and observation. These methods are however often expensive and/or time consuming and seldom functional in a clinical setting (8, 33). To accurately assess levels of PA in the general population can be challenging but even more so when assessing the levels of PA in people with physical disabilities, in particular in people that use wheelchair as mode of transportation. This is due to altered movement patterns but also reductions in muscle mass which reduces energy expenditure(33).

1.4.1 Physical activity self-report by questionnaires

The main reasons for the wide use of PA self-report by questionnaires are that is fast, cheap and easy to administer to bigger populations (34, 35). The biggest limitations with self-report are issues with recall and response bias. This could be due to inability to accurately determine level of intensity and social desirability(34). Many questionnaires have a floor effect i.e., they don’t capture the lower levels of PA which is troublesome for the most inactive population(35).

The Swedish National Board of Health and Welfare designed a short questionnaire consisting only of two indicator questions on PA (the BHW PA questions). It was created for two purposes, first to identify persons who are insufficiently physically active and second to evaluate levels of PA after some form of intervention(36). The BHW PA questions are validated on the able-bodied population and considered reasonably valid to capture the level of PA (36). A study from 2015 compared the validity of three different answer modes to the BHW PA-questions and it was found that categorical answer modes had the strongest concurrent validity in relation to accelerometer data. The different modes were open (how many hours and/or minutes per week), in table form (numbers of minutes each day from Monday to Sunday) and total time with categorical alternatives (0 min, <30 min, 30-60 min etc.)(36).

One SCI-specific questionnaire; Frågeformulär om fysisk aktivitet vid ryggmärgsskada (F-FAR) (English translation: Questionnaire on physical activity after spinal cord injury) was originally modelled after two other questionnaires on PA for persons with physical disabilities (described below) but created to better suit the SCI-population. The first version of F-FAR consisted of nine questions with follow-up questions a-c. The questionnaire examines weight training, exercise, and non-exercise PA (such as mode of transportation to work/studies, household chores, gardening etc.). F-FAR examines frequency, intensity, dose (in minutes) and what type of activity that is being performed. The original version of F-FAR was developed as part of doctoral studies at Karolinska University. The instrument was however not included in the thesis. The result of the development and evaluation of the instrument was reported in a study from 2014. F-FAR has been deemed to have satisfactory content validity(28). At present F-FAR is not being used in clinical practice.

Another SCI-specific questionnaire is called the Physical Activity Recall Assessment for People with Spinal Cord Injury (PARA-SCI). According to Ginis et al., the existing questionnaires for wheelchair users were deemed not suitable for the SCI-population, since the level of intensity was not addressed adequately(32). Therefore, a self-report questionnaire constructed as a semi-structured interview was made specifically for the SCI-population. PARA-SCI investigates all activities during three days in detail and then the interviewer accumulates total amount of PA(32).

Two other questionnaires made for wheelchair users but not specifically for the SCI-population is the Physical Activity and Disability Survey (PADS) and Physical Activity Scale for Individuals with Physical Disabilities (PASIPD). The design of PADS is a semi-structured interview and it examines PA in four different domains (exercise, leisure time PA, household activities and how much time is spent indoors at home)(37). One weakness with PADS is that does not assess the intensity of leisure time PA and there is just a single item to overall assess the intensity of structured exercise(33). PASIPD is a questionnaire with 13 items that queries for leisure time PA, household activities and activity related to work(38). The PASIPD uses standard MET-values as measure of intensity(33), which is as discussed earlier, questioned for the general population and even more for people with physical disabilities (31).

1.4.2 Physical activity assessed with accelerometer

An accelerometer is a movement sensor that collects data from three different orthogonal planes (anteroposterior, mediolateral, and vertical). It measures acceleration of bodily movements which are then used to estimate the intensity, (i.e. bigger acceleration equals higher intensity) of the PA being performed(39). Usually accelerometer data is analyzed as counts per minute, which are averaged into time periods, called epochs. The data is later sorted according to count thresholds also called cut-offs points for defining different levels of activity intensity(40). Two cut-off points that have been used for the able-bodied population are 2020 and 5999 counts per minute for moderate and vigorous intensity respectively(40). The most common wear time requested in studies when comparing accelerometer data with self-report questionnaires on PA are 7 consecutive days and >10 hours/day. Most studies that assess PA for a minimum of 7 days also require data from at least one day during weekend to consider the data valid(41). Tri-axial accelerometers placed on the wrist are found to be a good alternative for an objective way of measuring levels of PA in people who use wheelchairs according to a review from 2017(33).

The present study is part of a larger project that has already published two articles on resting energy expenditure and energy expenditure of 15 different activities for motor-complete paraplegia/tetraplegia. The energy expenditure was measured with indirect calorimetry(9, 10). Within this project one study aims to suggest accelerometer cut-off points for the SCI-population, data is collected and analyzed but not yet published.

1.5 Psychometric properties of self-report questionnaires

Validity is defined as: “the appropriateness, meaningfulness, and usefulness of the specific inferences made from test scores”(42). By this definition, meaning that validity testing of a self-report instrument is not validation of the instrument, but the results derived from it. The results can be used in different contexts and for multiple reasons, as for example, total amount of moderate to vigorous PA (MVPA), prediction of relative risk of disease, amount of energy expenditure or as way to classify individuals into being adequately physically active or not(43). One important step when validating a questionnaire is to define the targeted construct, in this case total amount of PA(43). According to the literature, self-report instruments for PA, needs to capture different dimensions of PA: duration, frequency and intensity(34).

Reliability and validity testing are the two main objectives when assessing psychometric properties of an instrument. This is to ensure that the instrument being used actually measures what it is supposed to measure i.e. targeting the construct of the instrument (construct validity). It is also of essence to investigate if the results from the instrument are stable regardless of when, who and how it has been used i.e. different forms of reliability(43).
There is indication that longer self-report instruments not always have higher validity or reliability than shorter ones. One explanation could be that respondents become confused and/or bored by lengthy instruments(35).

There is not an absolute consensus in the literature in how to use the concepts of validity and reliability. The terms concurrent and criterion validity are used interchangeably. The criterion validity is assessed by comparing the results from an instrument i.e. a questionnaire with another method of measuring the same construct preferably a gold standard. The two measurements are used concurrently, hence the expression concurrent validity. For determining the level of total amount of PA accelerometers are valid as criterion measurement(44) . The most common method for assessing criterion validity in self-report questionnaires against accelerometer data is correlation analysis(41). In general, validity coefficients tend to be weak in self-report instruments. One review found correlation results ranging from 0.14 to 0.53 (34). A large international validity evaluation of the International Physical Activity Questionnaire found the validity of 0.3 to be deemed acceptable(45).

1.6 Physical activity and SCI in a theoretical context

The International Classification of Functioning, Disability and Health (ICF) is a system for classifying different domains and aspects related to health(46). It is a biopsychosocial model of three domains of human function; body function, activity and participation that interact with personal and environmental factors(47). A SCI would be noted in the domain of body function as paralysis/muscle weakness and loss of sensory functions. But the SCI also affects activity and participation domains as one can expect difficulties in performing for example activities in daily living. Physical inactivity post-injury may lead to secondary complications such as increased dependency in activities in daily living for the SCI-population(48). Engaging in PA seems to have a positive impact on functional independence and lead to a higher quality of life for persons with SCI(48, 49). Social support and self-efficacy are important factors when aiming at empowering people within the SCI-population to become more physically active(50). Participation, in relation to organized sports for people with neurologic disabilities, seems to lower prevalence of depression and anxiety and increase self-esteem, self-concept, life satisfaction etc.(51).

Including examples of accessible activities actually performed by wheelchair users may increase the likelihood of an accurate assessment of PA level when using a self-report questionnaire. PA has an impact on many domains of the ICF for the SCI-population. To assess PA accurately is important when deciding on actions with the intent of improving health, body function and/or activity and participation. At present there is no gold standard questionnaire for the SCI-population for investigating levels of PA that is validated or used in the clinical setting.

2 Aim

There is a need for a time and resource effective clinical method of measuring level of PA in the SCI population. This could be used as clinical assessment of an individual's current level of PA but also as an evaluation of a training period. The overall aim with this study was to:

- Describe the criterion validity of two self-report questionnaires compared with accelerometer data in people with SCI.
- Investigate if there is any difference in validity between a specific SCI-self-report questionnaire compared with a generic questionnaire.

2.1 Method

2.1.1 Study design

Cross-sectional study for assessing the criterion validity of two self-report questionnaires on PA compared to objective data from wrist worn accelerometers worn during 7 consecutive days.

2.1.2 Participants and sample size

A total of nineteen participants were included. Inclusion criteria for the study was a chronic SCI (>1 year), resulting in a paraplegia AIS A or B (motor-complete), meaning full time wheelchair dependency. The participants had to understand spoken and written Swedish. Recruitment was performed at a SCI rehab center in Stockholm, by word-of-mouth and through advertisements in SCI-specific websites. All interested participants were given written information via e-mail and/or verbally. When uncertainty of injury level and AIS-classification permission was granted from the participant to collect the information from the medical record. Age, weight, length and date of injury were self-reported. All participants signed written informed consent.

2.1.3 Data collection

Data from the accelerometers and questionnaires was collected concurrently during the period of January 2018-June 2018. Each participant wore an accelerometer on the wrist on the dominant hand during all waking hours, for seven consecutive days. The instructions were to document the wear time i.e. at what time they put the accelerometer on in the morning and took it off when going to bed. The participants were not allowed to wear the accelerometer during shower/bath/swim training, which was also to be noted to ease data analysis when compared to self-reports. When returning the accelerometer, the participant completed the two questionnaires to be validated.

2.2 Equipment

The participants were fitted with the GT3X+ activity monitor (ActiGraph, Pensacola, FL). The accelerometers and the software Actilife version 6.8.1 were provided by Swedish school of health and education (Gymnastik och Idrottshögskolan).

2.3 The self-report questionnaires

F-FAR consisted of four main questions with follow up questions (a-c). F-FAR explored weight training, physical exercise in moderate and vigorous mode separately and moderate to vigorous intensity non-exercise PA. The questionnaire contained definitions of moderate and vigorous intensity. The question on non-exercise PA offered examples of activities of at least moderate intensity to ease classification of non-exercise PA. These examples were adjusted for wheelchair dependent responders. The written instruction in the questionnaire was to only count activity bouts of 10 minutes or longer. The amount of time was reported in categorical alternatives: ca 15 min, ca 30 min, ca 45 min, ca 60 min, >60 min. The original version of F-FAR also contained questions of PA level before the time of injury, season specific activities (for example skiing) and involvement in parasport. These questions were removed, (appendix 1).

The BHW PA questions were: 1. During a regular week, how much time do you spend exercising on a level that makes you short winded, for example running, fitness class, or ball games? 2. During a regular week, how much time are you physically active in ways that are not exercise, for example walks, bicycling, or gardening? Add together all activities lasting at least 10 minutes. The answer modes to these questions were designed as categorical with six different options for the first question (0 min, <30 min, 30-60 min, 60-90 min, 90-120 min and >120 min). The second question had seven options (0 min, <30 min, 30-60 min, 60-90 min, 90-150 min, 150-300 min and >300 min), (appendix 2).

2.4 Data analysis

The physical activity counts from the GT3X+ was downloaded in 15 seconds intervals for identification and summated into vector magnitude counts during 60 second epochs for analysis of time spent in different intensity levels. The cut-off points were stratified as sedentary >1700 counts per minute, light intensity 2997-9514 counts per minute, moderate intensity 9515-11960 counts per minute and vigorous intensity >11961 counts per minute. The accelerometer cut-off points were derived from measures on 38 persons with motor-complete paraplegia. The cut-off points were based on measurements of indirect calorimetry from two sedentary activities and wheeling indoors/outdoors at different speeds/intensities, setting table, standardized track and test of peak effort. Moderate intensity was set at 50% of VO_2 peak(24) and was deemed to associate with 9515 counts per minute. To create the accelerometer cut-off points receiver operating characteristics (ROC-curve) analysis was used and resulted in sensitivity of 85.5 and specificity of 87.5 with an area under curve of 0.936 for the cut-off point 9515 counts per minute for moderate intensity.

All data was analyzed with SPSS version 24.0 and Microsoft excel spreadsheet version 16.16.2. All data was visually checked for normality and Shapiro-Wilk test. Normally distributed data is presented as mean and ±SD. Non-normally distributed data is presented as median and interquartile range (IQR). Due to non-parametric data Spearman's rho was used for assessing correlation. The data from BHW PA questions was nominal and handled as scale ranging from minimum 3 to 19 as maximum scores. The total score of the BHW PA questions were derived through doubling the score from the first question (exercise question) and after that adding the sum from the second question (non-exercise PA) thus generating a total PA volume defined as activity minutes. The doubling of minutes has been used a way to account for higher intensity(36). The score ranged from 3 to 19 where 3 was the lowest total score meaning a low level of PA whereas 19 a high level of PA both in exercise mode and a non-exercise PA(36). All but two participants had valid wear time for all seven days, i.e., >600 min/day. The days with <600 min were excluded and new days were constructed by dividing the total sum of MVPA in minutes with the number of valid days and then multiplying by seven (52). Due to technical error of an accelerometer one participant was excluded from total analysis. A correlation result of 0.5-0.7 is considered a moderately strong correlation(53).

2.5 Ethical conduct

The study was a part of a bigger project, which received ethical approval by Stockholm regional ethical committee, assigned reference number 20011/1989-31/1. The participants were informed on the possibility that they at any time could terminate the participation of the study without any given reason and that would not affect future contact with Rehab Station and their outpatient SCI-unit Spinalis (the primary health care center for issues related to the SCI). The participants had the opportunity to ask questions before signing written informed consent. The results from the questionnaires and key for identifying the participants are kept in separate archives at Rehab Station Stockholm.

3 Results

A total of 18 participants were included, however one participant was excluded from the analysis of the BHW PA questions because of missing data. The proportion of female participants in the study population was 28%. More than half (56%) of the participants had a low level of injury(T10-L1), compared to those with an injury level of T3-T9. Age ranged from 21-66 years. Years since injury ranged from 2 to 46 years. Fifty-six percent of the participants had been injured ≥ 6 years. Table 1.

Table 1. Characteristics of participants (n=18). Mean, (±SD)

Age (years)	47 ±14.5
Men/women	13/5
Height (cm)	177 ±7.9
Weight (kg)	74 ±14.2
Years since injury	6.5* (IQR 28)
Level of injury	
T 3	1
T 4	2
T 5	1
T 6	2
T 8	1
T 9	1
T 10	2
T 11	2
T 12	5
L 1	1

cm=centimeter, kg=kilogram, T=thoracic, L=lumbar, *=median, IQR= interquartile range

Table 2. Correlation between self-reported physical activity and accelerometer data

	Median (IQR)	**Correlation (r)**	**p-value**
Accelerometer, minutes in MVPA (n=18)	149 (200)	n/a	n/a
F-FAR, minutes in MVPA (n=18)	285 (443)	0.574*	0.013
BHW PA questions (n=17)	14 (5)	0.337	0.186

All results in Spearman's rho, MVPA=moderate to vigorous physical activity, n/a= not applicable, F-FAR=Frågeformulär om Fysisk Aktivitet efter Ryggmärgsskada, BHW PA questions=Swedish National Board of Health and Welfare physical activity questions, IQR=interquartile range, *= p<0.05

There was a statistically significant correlation between the results of F-FAR and accelerometer data as shown in table 2. There was no significant correlation between the two questionnaires (r=0.414, p=0.099).

The median value of accelerometer data was 149 (IQR83-283) minutes of MVPA/week versus a median of 285 (IQR101-544) minutes for F-FAR. Five participants reported lower levels of MVPA, according to F-FAR, compared to accelerometer data. Sixty-seven percent of the participants reported activity levels >150 minutes/week in F-FAR. According to results from accelerometer 50% of the participants reached >150 minutes. Three participants reported <50 minutes of MVPA in F-FAR but had scores from BHW PA question between 13-17.

Table 3. Accelerometer data and self-reported moderate to vigorous physical activity for each participant (n=18)

Accelerometer MVPA min/week	F-FAR MVPA min/week	BHW PA questions scale 3-19*
202	390	13
92	0	13
124	1090	10
32	45	17
277	135	15
76	15	6
127	225	13
68	120	9
172	1200	17
333	825	19
83	45	14
126	225	11
300	300	n/a
253	270	15
401	315	15
320	450	13
81	300	18
171	1140	19

MVPA=moderate to vigorous physical activity, n/a= not applicable due to missing data, F-FAR=Frågeformulär om Fysisk Aktivitet efter Ryggmärgsskada, BHW PA questions=Swedish National Board of Health and Welfare physical activity questions, * scores ranging from 3-19. Three equaling low level of PA and 19 high level of PA in both exercise and non-exercise PA.

4 Discussion

Main results from this study are that there was a significant and moderately strong correlation between accelerometer data and the SCI-specific F-FAR while the generic BHW PA questions showed slightly weaker and non-significant results.

The correlation between F-FAR and accelerometer data was in concordance, but also higher, when compared to other studies. Even though the correlation between F-FAR and accelerometers was 0.574 and considered moderate other studies have found a validity coefficient of 0.3 to be acceptable(34, 45). A similar validation study for the SCI-specific instrument PARA-SCI deemed the correlations to be strong for moderate, heavy and total activity, (r 0.63-0.88) but low levels of agreement when compared to accelerometer data(32, 54). However, in contrast to F-FAR the PARA-SCI is more resource intensive. It was designed as an interview-based questionnaire, which demands one person to perform the interview and the estimated time for interview 20-45 minutes. Moreover, the PARA-SCI might have limited use for other users, than the developers, due to its technical complexity(33). In comparison, the generic BHW PA questions were designed as an only two indicator question form but this short form was not able to capture the amount of PA within the SCI-population. The phrasing of the examples in BHW PA questions were put as walking and running. This might have influenced the result in a negative direction since these activities are not accessible for the SCI-population and therefore not proper examples for grading levels of intensity. When assessing the validity of the BHW PA questions in general population the correlation between percentage of MVPA/day and accelerometer data it was found a correlation of 0.27 which was lower than the present study but the result was however significant(36).

The estimated amount of PA according to the questionnaires was in general higher than the results from accelerometers. This is similar to previous results. A review that compared self-report and objective measures, found that self-report measures generally generated higher results than accelerometer data(55). Three participants reported in F-FAR over 1000 minutes in MVPA, while the accelerometer had results of 124 – 172 minutes. This shows the discrepancy between the reported and measured time in MVPA (table 3). One explanation to this discrepancy could be due to inability in determining levels of intensity correctly. F-FAR did not seem to be able to capture the individuals that were moderately physically active. The participants however, who had lower levels of PA scored more accurately. In clinical practice it is more important to find individuals that have insufficient levels of PA. According to Hagströmer and Bowles validation checklist for PA instruments, it is important to include participants with a wide range of PA levels to ensure that the measurement is valid for individuals with varying activity levels(56). According to the results from accelerometers the sample had a wide spread from 32-401 minutes of weekly MVPA. Even though the results from the BHW PA questions were normally distributed there was a tendency to estimate level of PA fairly high with a median of 14, which was only 5 points less than maximum score.

One key difference between the two questionnaires was the wording. The BHW PA questions asked for level of PA of an ordinary week and the F-FAR specifically asked for PA-level of the last week. These different recall periods could perhaps help to explain the differences in result from the two questionnaires in F-FAR’s favor. A previous study found a preference for using recall of the last seven days over recall of a usual week which seemed to be due to difficulties in identifying a usual week(45).

The cut-off points used in this study were specific for motor-complete paraplegics. Other studies that have suggested accelerometer cut-off points for wheelchair users had more heterogeneous study samples. One study suggested a SCI-specific cut-off point for moderate intensity of 11 652 counts per minute. Although, SCI-specific, it was a heterogeneous sample with regards to injuries ranging from C5 to L2. Further, it was not described if the injuries were motor-complete or not (57). Learmonth et al suggested a cut-off point of 3644 counts per minute for moderate intensity but the study sample consisted of a wide range of conditions including both neurological and orthopedic injuries (58). These fairly different cut-off points would render completely different results.

It is a challenge to adequately determine intensity levels in PA which has been shown to influence the results in validation studies(34). Many self-report questionnaires on PA often use perspiration as way to define intensity of activities. F-FAR contained descriptions of intensity that in addition to breathing more heavily there was another example of feeling strained as measure of higher intensity. This could have had a positive effect in that it was easier to relate to the descriptions of the intensities even for persons with higher levels of injury. The generic BHW PA questions did not include any examples of different levels of intensity for defining exercise nor non-exercise PA.

Even though an objective measure as accelerometer is suggested to be gold standard when validating self-report questionnaire for PA there are contradicting standpoints. Troiano et al., argues that accelerometers and self-report measures are distinct, not equivalent(59). Masse and de Niet agrees with Troiano and state that accelerometers conceptually don’t measure the same outcomes as self-report instruments do(60). PA is a complex behavior and trying to fully capture all dimensions in a questionnaire or as objective data might be hard. Depending on which dimension one wishes to capture, sedentary behavior, total amount of PA, intensity of PA et., maybe different approaches are to be used. Kelly et al argues that a combination of subjective and objective measures might be the most useful approach when trying to understand something as complex as PA(44). Questionnaires could be useful as a starting point when discussing PA, exercise and a change of behavior. An accelerometer is more likely suitable when assessing the total amount of PA during a specific time period and as a tool to, in pedagogical way, describe activity or inactivity patterns. For a deepened insight in PA level and behavior, modern technology now offers adjusted and easy to use tracking of wheelchair activities that could might be used as a complement to PA assessment with questionnaires.

4.1 Methodological considerations

A strength of the study was high compliance and very little missing data. Analysis was based on 98.4% of valid data (124 of 126 days valid wear time days), in comparison with larger accelerometer studies who presented 70-80% of at least 6 valid days(59). The sample consisted of 72% men, which is approximately similar to the distribution in the Swedish SCI-population. The sample size was in concordance to a similar validation study who deemed it sufficient with a sample size of 15 participants(54).

The population in the present study reported a median weekly amount of 285 minutes of MVPA. A Swedish study from 2014, using self-report, presented a weekly mean of PA of 172 MVPA minutes(28). The lower levels of self-reported PA could be related to that also persons with tetraplegia were included. The abovementioned study used the original version of F-FAR. In a study by Rocchi et al on self-reported levels of PA, 44% of the participants reported 0 minutes of PA during the seven days investigated(19). It seems that the present study might have a higher number of physically active participants than general in the SCI-population. Although, the objective with the study was not to assess PA-levels within the SCI-population and therefore the study sample would not be considered biased.

The rationale for removing three questions from the original version of F-FAR questions was that they would not have an impact on the actual level of physical activity. In the original version one question asked for mode of transportation to work/studies, this question was included in question four that examined non-exercise PA.

This study was limited by a few factors. The preferred approach when validating measurement on PA is the Bland-Altman plot that investigates the level of agreement between the two instruments(55). However, the results from F-FAR was not normally distributed thus non-parametric analysis was used. Had it been the case with normally distributed data a stronger conclusion of the appropriateness of F-FAR could have been made.

Accelerometers have been found to be a valid method and an acceptable criterion measure for assessing and validating PA in wheelchair users(33). However, the questionnaires queried for PA of bouts of 10 and 15 minutes respectively. The accelerometers were analyzed as total amount MVPA during the seven days. Therefore, shorter bouts than 10 minutes might not have been registered in the questionnaires but as time spent in MVPA by the accelerometer. In the analysis weight training (question 1 in F-FAR) was not included with the rationale that is has been found that energy expenditure from weight training in machines correlates poorly with accelerometers (54).

4.2 Implications for clinical practice

Raising awareness of the importance of PA and exercise in relation to health is central in physiotherapeutic care of the SCI-population. At present there is no standardized manner in measuring PA in the SCI-population. The result from this study support that F-FAR could be used as a first step of assessing level of PA in the target group. When implementing new instruments in clinical practice time and resource needs to be considered. F-FAR is a questionnaire of two pages and estimated time to complete is around five minutes.

4.3 Implications for further studies

To use F-FAR for evaluating an intervention with aim to increase level of PA reliability needs to be investigated further(44). The study sample was motor-complete paraplegics, a future study is recommended for validating the F-FAR on motor-complete tetraplegics. The aim of the study was not to establish whether or not this subpopulation of SCI reached the recommended levels of PA. This however is a very interesting question that in the future needs more accurate answers. Comparing levels of PA during different seasons would be of interest, this since wintertime has its challenges, which most likely affects the ability to perform PA and exercise. Level of PA and its correlation to health parameters in the SCI-population needs more research.

5 Conclusion

The results of the present study were that there was a significant correlation between the SCI-specific self-report F-FAR and accelerometer data but not for the generic BHW PA questions. Based on the results from this study the self-report questionnaire for PA, F-FAR, is a promising method to capture PA levels in persons with SCI. This finding further indicates that F-FAR could be used in a clinical setting. The non-significant correlation to the generic and shorter BHW PA questions, developed for general population, indicates that a SCI-specific questionnaire might be a more appropriate method.

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Appendix 1

Praktikertjänst REHAB STATION

FRÅGEFORMULÄR OM FYSISK AKTIVITET VID RYGGMÄRGSSKADA

Datum:
Namn: ________________________ Födelseår:__________

Ryggmärgsskadad sedan år: ______ Skadenivå: ______
Nedan följer ett antal frågor om fysisk aktivitet vid ryggmärgsskada. Svara på frågorna som följer och kryssa för det svarsalternativ som bäst beskriver din situation. Kryssa endast i en ruta per fråga. **OBS!** Räkna bara aktiviteter som du gjort <u>minst 10 minuter i sträck.</u>

<u>**Styrketräning**</u>
1 a. Hur ofta har du styrketränat den senaste veckan?
Om du kombinerar styrke-och exempelvis konditionsträning vid samma tillfälle fyll då även i konditionsträning under motion och träning.

- ☐ Aldrig
- ☐ 1 - 3 gånger/månad
- ☐ 1 gång/vecka
- ☐ 2 gånger/vecka
- ☐ 3 gånger/vecka
- ☐ Fler än 3 gånger/vecka. Ange hur ofta/vecka: ______

1 b. Ange på vilket sätt du styrketränat den senaste veckan:

____

<u>**Motion och träning**</u>
Uttrycket **”något ansträngande”** fysisk aktivitet innebär att du andas något kraftigare än normalt och att du kan fortsätta utan större besvär.

Uttrycket **”ansträngande till mycket ansträngande”** fysisk aktivitet innebär att du andas mycket kraftigare än normalt och att du är trött men kan ändå fortsätta. Alternativt att du upplever en mycket stark påfrestning, du kan fortsätta men måste ta i mycket kraftigt och känner dig mycket trött.

2 a. Hur ofta har du motionerat/tränat på en *något ansträngande* nivå den senaste veckan? Ta inte med aktiviteter du eventuellt redan angivit i frågan om styrketräning.

- ☐ Aldrig
- ☐ 1 - 3 gånger/månad
- ☐ 1 gång/vecka
- ☐ 2 gånger/vecka
- ☐ 3 gånger/vecka
- ☐ Fler än 3 gånger/vecka. Ange hur ofta/vecka: ________

Om du svarat *aldrig* gå vidare till fråga 2, i annat fall fortsätt här nedan:

2 b. Uppskatta hur många minuter du spenderat i genomsnitt per gång på *något ansträngande* nivå

- ☐ ca 15 minuter/gång
- ☐ ca 30 minuter/gång
- ☐ ca 45 minuter/gång
- ☐ ca 60 minuter/gång
- ☐ Men än 60 minuter/gång. Ange minuter/gång: __________

2 c. Ange dina motions-och/eller idrottsaktiviteter på en *något ansträngande* nivå:

____

1

3 a. Hur ofta har du motionerat/tränat på en *ansträngande till mycket ansträngande* nivå den senaste veckan?

- Aldrig
- 1 - 3 gånger/månad
- 1 gång/vecka
- 2 gånger/vecka
- 3 gånger/vecka
- Fler än 3 gånger/vecka. Ange hur ofta/vecka: ____________

Om du svarat *aldrig* gå vidare till fråga 4, annars fortsätt här nedan:

3 b. Uppskatta hur många minuter du spenderat i genomsnitt per gång på *ansträngande till mycket ansträngande* nivå.

- ca 15 minuter/gång
- ca 30 minuter/gång
- ca 45 minuter/gång
- ca 60 minuter/gång. Ange minuter/gång: ______________

3 c. Ange dina motions- och/eller idrottsaktiviteter på en *ansträngande till mycket ansträngande* nivå:

____

<u>Övrig fysisk aktivitet</u>

Exempel på övriga fysiska aktiviteter kan vara att transportera sig till arbete/studier och andra aktiviteter med manuell rullstol, cykel och/eller till fots. Det kan också vara hushållsarbete (städa, duka, plocka i/ur diskmaskinen, gå och handla), trädgårdsarbete, vedhuggning/snöskottning, snickra, måla, aktiviteter med många upprepade tunga luft samt lek och spel.

4 a. Hur ofta har du förutom eventuell styrketräning, motion och träning i övrigt varit fysisk aktiv på minst *något ansträngande* nivå den senaste veckan? Ta inte med de aktiviteter du eventuellt redan angivit i frågorna om styrketräning samt motion och träning. Räkna bara aktiviteter som du gjort <u>minst 10 minuter i sträck.</u>

- Aldrig
- 1 - 3 dagar/månad
- 1 dag/vecka
- 2 dagar/vecka
- 3 dagar/vecka
- Fler än 3 dagar/vecka. Ange hur ofta/vecka: _______________

4 b. Uppskatta hur många minuter du spenderat i genomsnitt dessa dagar på minst *något ansträngande* nivå

- ca 15 minuter/dag
- ca 30 minuter/dag
- ca 45 minuter/dag
- ca 60 minuter/dag
- Mer än 60 minuter/dag. Ange minuter/dag: _________________

4 c. Ange dina övriga fysiska aktiviteter på minst *något*

***ansträngande* nivå**____

Tack för ditt deltagande!

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Appendix 2

Praktikertjänst
REHAB STATION

Socialstyrelsens indikatorfrågor om fysisk aktivitetsnivå

Hur mycket tid ägnar du en vanlig vecka åt fysisk träning som får dig att bli andfådd, till exempel löpning, motionsgymnastik eller bollsport?

☐ 0 minuter/Ingen tid

☐ Mindre än 30 minuter

☐ 30–60 minuter (0,5–1 timme)

☐ 60–90 minuter (1–1,5 timmar)

☐ 90–120 minuter (1,5–2 timmar)

☐ Mer än 120 minuter (2 timmar)

Hur mycket tid ägnar du en vanlig vecka åt vardagsmotion, till exempel promenader, cykling eller trädgårdsarbete? Räkna samman all tid (minst 10 minuter åt gången).

☐ 0 minuter/Ingen tid

☐ Mindre än 30 minuter

☐ 30–60 minuter (0,5–1 timmar)

☐ 60–90 minuter (1–1,5 timmar)

☐ 90–150 minuter (1,5–2,5 timmar)

☐ 150–300 minuter (2,5–5 timmar)

☐ Mer än 300 minuter (5 timmar)