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Relationship between patterns of daily physical activity and fatigue in cancer survivors

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A B S T R A C T

Purpose: This study investigated: (1) physical activity behaviour of cancer survivors throughout the day, (2) the relationship between objective and subjective measures of physical activity, and (3) the relationship between daily physical activity and fatigue.
Method: Physical activity was measured objectively using 3D-accelerometry (expressed in counts per minute (cpm)), and subjectively using a Visual Analogue Scale (VAS; 0–10) implemented on a smartphone in 18 cancer survivors (6 male; age 55.7 ± 10.2 yrs; free from cancer, last treatment ≥three months previously), and matched controls. Fatigue was scored thrice daily on a smartphone (0-10 VAS).
Results: Mean daily physical activity of cancer survivors did not deviate from controls (1108 ± 287 cpm versus 1223 ± 371 cpm, $p = .305$). However, in cancer survivors physical activity significantly decreased from morning to evening ($p < .01$) and increased levels of fatigue throughout the day were reported ($p < .01$). Furthermore, a positive correlation was found between levels of fatigue and the magnitude of the decline in physical activity from afternoon to evening ($p < .05$). Objective and subjective measured physical activity showed low correlations.
Conclusions: This study demonstrated imbalanced activity patterns in cancer survivors. Also, the more a survivor felt fatigued, the greater the decline in activity behaviour throughout the day. The low correlation between objective and subjective physical activity suggests low awareness in cancer survivors about their daily physical activity performed. Ambulatory monitoring provides new insights in both patterns of physical activity and fatigue, which might be a valuable tool to provide activity management more efficiently during treatment of fatigue.

Introduction

Cancer-Related Fatigue (CRF) often interferes with the performance of daily activities (Curt et al., 2000), can have devastating social and economic consequences (Flechner and Bottomley, 2002) and may even hinder the chance of remission or cure as a result of its demotivating effects (Morrow et al., 2002). Not surprisingly, CRF is perceived by both patients and caregivers as a highly distressing and debilitating symptom.

It is generally believed that physical activity (PA) is important in the treatment of CRF (Cramp and Byron-Daniel, 2012). Existing guidelines state that improvements to a patient's level of physical fitness and normalization of levels of daily activity, a process termed activity management, are important treatment goals for CRF management (Donnelly et al., 2010; Mitchell et al., 2007; Smith and Toonen, 2007). Moderate PA is associated with the alleviation of cancer-related symptoms such as fatigue (Cramp and Byron-Daniel, 2012), and the beneficial effect of activity management on fatigue in patients undergoing cancer treatment has been demonstrated in several randomized controlled studies (Barsevick et al., 2004; Ream et al., 2006; Yates et al., 2005).

Most of the studies examining PA and fatigue in cancer survivors have used retrospective outcome measures, such as questionnaires, to capture the extent and the nature of PA. Although these measures provide a general idea of the amount of PA performed,

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previous studies involving cancer survivors demonstrated a discrepancy between PA measured retrospectively with questionnaires and PA measured using objective measures such as accelerometers (Goedendorp et al., 2010; Grossman et al., 2008; Rogers et al., 2009; Servaes et al., 2002). A likely explanation for the discrepancy is that questionnaires are prone to recall bias. When people are asked to recall past behaviour, only a part of that behaviour will be recalled, depending on the question asked, the frequency, severity, or impact of the behaviour in question (Shiffman et al., 2008). For example, for PA behaviour it is known that light or moderate PA is difficult to measure using questionnaires (van Poppel et al., 2010); one is likely to forget 'normal', daily PA, but will recall high intensity bouts of activity.

Ambulatory monitoring techniques can provide more accurate and detailed information on daily PA behaviour and fatigue (Broderick et al., 2014). Ambulatory monitoring uses objective methods (e.g. accelerometers), subjective methods (e.g. symptoms scored several times during a day), or a combination of both, to capture behaviour as it occurs in patients' daily life. So far, only a few studies have employed ambulant monitoring, such as accelerometry, to capture PA in cancer survivors (Broderick et al., 2014). The results are surprising, as contrary to the studies using questionnaires, only a minority of these studies report lower levels of PA in cancer survivors as compared with healthy controls (Knols et al., 2009), while the majority report no differences in PA level (Alt et al., 2011; Ferriolli et al., 2012; Grossman et al., 2008). Even so, the expected relationship between PA and fatigue is scarcely observed when evaluated using ambulant monitoring. Only one study reported a significant – but low – correlation between an increase in daily steps and a decrease in fatigue in adult survivors of childhood cancer (Blaauwbroek et al., 2009).

Most of the studies that objectively assessed PA in cancer survivors used parameters that related to the *amount* of PA performed (such as intensity, number of steps, or total amount of daily PA). However, PA is not only a 'multi-dimensional construct incorporating frequency, time, type and duration' (Broderick et al., 2014), but also a behaviourial construct, concerned with patterns of PA within a specific time period (Broderick et al., 2014). To illustrate, for other populations who suffer from chronic disease, it has been reported that not the amount of PA, but PA *behaviour* might be a useful predictor of health outcomes (Evering et al., 2011a,b; van Weering et al., 2009). So far, there are no studies evaluating patterns of PA reported in the cancer literature. Therefore, better insights into both PA behaviour in cancer survivors and its relation to self-reported fatigue are desirable.

When discussing the role of PA behaviour in CRF management, another important aspect is 'awareness'. Awareness is considered essential for effective behaviour change (Pinto and Ciccolo, 2011), and is therefore a prerequisite for treatments that aim to change activity behaviour such as activity management. No previous study could be found that explicitly evaluated awareness of daily PA behaviour in cancer survivors.

Therefore, to explore the potential value of PA behaviour in CRF treatment, this study: (1) assessed PA behaviour throughout the day in a pilot group of cancer survivors; (2) compared objective and subjective ambulatory monitoring techniques to gain insights into the level of awareness of cancer survivors with regard to their daily PA performed; and (3) explored the relationship between specific parameters of daily PA pattern and self-reported fatigue in cancer survivors.

Methods

A cross-sectional study was performed at the Roessingh Center for Rehabilitation, Enschede, the Netherlands. The experimental protocol was approved by the Twente Medical Ethics Committee, and informed written consent was obtained from each participant before enrolment.

Participants and setting

Cancer survivors were recruited from the Roessingh Rehabilitation Center Enschede, the Netherlands. Inclusion criteria were: (1) formerly diagnosed with cancer; (2) completed cancer treatment (i.e. surgery, chemo- and/or radiotherapy) $\geq$3 months previously; (3) ability to read and speak Dutch; and (4) aged 18 or above. The exclusion criteria were: (1) use of wheelchair; (2) terminal or progressive disease; and (3) participation in a rehabilitation program in the previous three months.

For comparison of *daily activity behaviour*, a sample of healthy controls was included in the study. Controls were recruited by asking the patients to ask their spouses to participate. The sample of healthy controls was supplemented with controls selected from a database available at the research center. This database consisted of family members from both patients included in other studies and from employees or students working at the research center. The controls were selected from the database based on their age and sex, so that the two groups were comparable in terms of age and sex. Inclusion criteria for healthy controls were: (1) 18 years or older; (2) subjective report of being healthy; (3) no history of cancer. The same exclusion criteria applied for the controls as for the main cancer survivor group.

Procedures

Eligible cancer survivors and controls were approached by the first and second authors, who provided verbal and written information about the study. Subjects who were willing to participate were asked to fill in an informed consent. On the morning of the first day, the procedure was explained and demographic characteristics were recorded for each participant. After that, participants filled in a questionnaire about fatigue. Instructions were given about the use of the equipment, namely an activity sensor and a smartphone. Instructions covered the correct placement of the accelerometer and the wearing schedule. Participants were asked to wear the accelerometer and smartphone for five consecutive days from 8:00 until at least 22:00, excluding time spent bathing or participating in water activities. Participants were also asked to perform their normal, daily routine, and to not change their physical activity pattern. After instruction, the accelerometer and smartphone were given to the participants, and returned by post or in person to the research center after five days of monitoring.

Study measures

For each participant, the following personal information was recorded: age, sex, BMI, and current work status. For survivors, the following information was added: treatment received, location of cancer and months passed since final cancer treatment.

Ambulatory measures – Cancer survivor and controls

Objective PA behaviour was assessed using the MTx inertial 3-D motion sensor (XSens Technologies B.V., Enschede, the Netherlands), which is a tri-axial piezoelectric accelerometer that measures accelerations in the *x*, *y*, and *z*-axis. This sensor was attached to the waist by means of an elastic belt. Data were transmitted wirelessly through a Bluetooth connection and stored on a smartphone. The output measure was calculated following the method described by Bouten et al. (1994), which is highly related to measuring energy expenditure (Plasqui and Westerterp, 2007). The