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Student Name: Gail Pollard **Date:** August 6th, 2014

Project Title: Measuring Postural Changes and Sedentary Behaviour in Patients After Knee Replacement

Primary Supervisor Name: Dr. Sandra Webber
Department: Department of Physical Therapy, School of Medical Rehabilitation

SUMMARY: Negative health consequences are associated with prolonged sedentary behaviour. Patients who require total knee replacements tend to be obese and sedentary and often do not increase activity levels post-operatively despite reductions in pain.

Objectives: The purpose of this study was to determine the accuracy of ActiGraph and activPAL activity monitors in categorizing posture (e.g. sitting versus standing) in total knee replacement patients. Secondarily we were interested in examining data collected over 7 days as patients went about their normal routines.

Methods: Forty patients (50-80 years of age) wore an ActiGraph GT3X+ monitor on their waist and an activPAL monitor on their thigh during their 5-8 week post-operative visit with the surgeon. The patients were directly observed during this visit and all activity and postural changes were recorded for comparison with the activity monitor data. To further characterize the participants, height, weight, knee range of motion and 10m walk speed were also measured. Participants who were interested were then asked to wear an activity monitor over the next 7 days while they went about their normal routine.

Results/conclusions: The activPAL had significantly better accuracy in detecting sedentary and upright postures (paired t-tests $p<0.05$). There was a significant difference in sedentary predictive values ($p<0.05$) with the activPAL having a better predictive value. No significant difference was found between monitors for upright predictive values. Ten participants spent an average of 73.36% (+/- 10.77%) of monitor wear time in sedentary behaviours. This is more than research has shown in healthy populations.

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Introduction

Interest in studying sedentary behaviour has recently evolved as a popular area of health research. Unfortunately, the term “sedentary” has often been used to describe individuals who do not meet physical activity guidelines rather than to describe habits associated with sedentary activities. Examples of sedentary behaviour include sitting, driving and watching television. It is defined by either a lack of, or very low intensity physical activity associated with low energy expenditure (<1.5METS) (1;2). Sedentarism is the prolonged participation in sedentary behaviours and extended periods of rest. Prolonged sitting time has been identified as a unique health risk which is independent of overall physical activity level. Studies have now begun to investigate how sedentary behaviour itself effects health outcomes (3).

New evidence demonstrates that sedentary time is associated with numerous poor health outcomes, including an increased risk of obesity, type 2 diabetes, cardiovascular disease, and premature mortality (4). Studies have found that healthy, predominantly overweight individuals spend 60%–66% of their waking hours in sedentary behaviours (5-7). Similarly a global assessment conducted in more than 60 countries determined that the elderly had the highest prevalence of sedentary behaviour, reporting a minimum of 4 hours of sitting time daily (8). It seems that the minimum recommended guidelines for physical activity are no longer sufficient for achieving positive health outcomes, but rather the timing of the physical activity may be more important especially in older adults and those with mobility issues. Focussing on the “non-exercise part of the activity continuum”(9) is a relatively new and perhaps a more realistic approach to investigating the health implications of sedentary behaviour. The importance of using a whole-day approach to physical activity has also been the subject of various studies (4;5;8;10-19). This approach, which stresses reducing sedentary time and increasing light intensity activity, is perhaps most relevant in those with mobility issues. Such individuals are commonly amongst the most inactive of the population and meeting the minimum physical activity guidelines(20), recommended for health is often a challenge for them.

Patients post total knee arthroplasty (TKA) are perhaps one of the most at risk target populations health wise. Patient expectations of total knee arthroplasty are not always met, particularly those expectations related to increasing physical activity and weight loss. In a population of patients one year after receiving total knee arthroplasty surgery, almost half of them did not meet the minimum physical activity guidelines for health benefits (14;21). This may be due to a large percentage of time spent in sedentary activities, often a learned behaviour during the progression of disabling osteoarthritis (the most common reason for TKA). Increasing physical activity and reducing sedentary behaviour is particularly relevant as these individuals are often affected by mobility limitations. Research indicates that these patients are often unable to regain full function in the involved knee(s) (22-24) and daily physical activity levels lag behind those of healthy individuals in the same age group (25-28). This is a concerning trend as the majority of these patients are overweight or obese, frequently have multiple risk factors for cardiovascular disease, and would benefit greatly from reduced sedentary behaviours and increased physical activity (29;30). Recent data indicates that most people who have knee replacements actually gain weight in the years after surgery (31;32), which further compounds their risks for cardiovascular complications (33), progression of osteoarthritis in other weight-bearing joints (34), and excessive wear on the joint prosthesis itself (35). The waiting period for elective TKA can be months or even years and many conditions, including osteoarthritis continue to progress and the patient’s health and function deteriorate while awaiting surgery. As patients await surgery the progressive worsening of their condition often increases the time spent in sedentary behaviours and the time they spend in activities of daily living often decreases due to fatigue, pain, or a loss of motivation (36).

It is thought that after surgery, return to normal physical activity is often not attained. A few objective studies using accelerometer technology (25;37) determined that in an average 24 hour period, patients spend approximately 8.1 hours in movement/physical activity before TKA. At 6 months post-surgery, this time increases to 9.1 hours. This is only a 6% increase in physical activity. The changes found suggest that 6 months after surgery, the activity level had not approached that of healthy subjects. In contrast to a large effect on pain, stiffness and self-reported physical functioning, improvement in actual physical activity was less than expected 6 months after surgery(37). Many studies which have looked at physical activity levels in patients after total knee arthroplasty (14;36;37;54-57) have used self-administered questionnaires to obtain their data. Self-report questionnaires commonly used to assess physical activity and sedentary behaviour, have a number of limitations including recall bias, socially desirable responses, and the influence of mood, cognition, and disability on responses (38). This approach to studying sedentary behaviour tends to focus on screen-based viewing behaviours which don’t capture the entire sedentary behaviour spectrum. Accelerometer technologies measure a spectrum of sedentary and light intensity activities, and are a promising tool for research. These devices are able to detect time spent being active but their accuracy in detecting specific sedentary behaviours has not been extensively researched (39)

The activPAL and ActiGraph are the most popular research accelerometers for measuring physical activity and make studying physical activity and sedentary behaviour increasingly more accurate and easy. (6;11;15;19;39-45). Worn on the hip, the ActiGraph monitor provides two types of information; physical activity intensity (activity count) measurements and inclinometer information. Both types of information are used by the monitor to determine posture. The inclinometer functions to detect standing, lying, sitting and “off” (40). The ActiGraph measures acceleration in three axes at a sampling rate of 30 Hz-100 Hz and can produce data in as little as 1 second samples (epochs)(46). The activPAL, which is also a small lightweight (15g) activity monitor, is worn on the front of the thigh. Unlike the ActiGraph, the activPAL is a uni-axial accelerometer which summarizes data in 15 s intervals (epochs) at a sampling frequency of 20 Hz (47). Because it is worn on the thigh, the activPAL is unable to distinguish between sitting and lying postures. Similarly, because it is worn on the hip, the ActiGraph has difficulty distinguishing between sitting and standing postures.

Recent studies are focussing more so on the specific use of accelerometer technology. The use of such technologies is less time consuming and more accurate. Both the ActiGraph and activPAL were validated in a study specifically looking at sedentary behaviour (42). In another study, three accelerometers, including the ActiGraph, were analysed for their effectiveness (11). Each of the three technologies was assessed for their accuracy in recording various sedentary and light-intensity activities in healthy subjects. All three monitors were able to measure sedentary behaviours as well as light-intensity activities with relative accuracy (11). Most studies to date (6;11;15;19;39-45) were performed with healthy participants without physical mobility issues that often interfere with the ability to perform higher intensity physical activity. A healthy body mass index (18.5-24.9) is the norm in studies looking at sedentary behaviour and there is a knowledge gap in terms of how an increased BMI may affect the accuracy of the activPAL and ActiGraph monitors. Also, the performance of various postures and activities within a controlled environment can often be quite different than their performance under normal circumstances. In assessing whether or not a device can differentiate between sedentary and light intensity activities, it is important to test this ability under everyday circumstances.

Objectives: The primary objective was to determine the accuracy of the activPAL and ActiGraph GT3X+ activity monitors in categorizing common daily activities in terms of anatomical position (sitting, standing, lying) in patients approximately 6 weeks post total knee arthroplasty. The secondary objective was to collect activity monitor data over 7 days in these same patients to begin to understand physical activity and sedentary behaviour patterns in these individuals in their “natural” environment.

Materials/Methods

Participants: Forty participants (mean age 66.15 years +/- 8.05, BMI 32.86 kg/m^2 +/- 8.59), 24 females and 16 males, who recently had primary elective total knee arthroplasty surgery were recruited to participate in this study through the Concordia Hip & Knee Institute. Eighteen patients used a cane, 4 used a walker, and 18 did not require a gait aid. Out of the 40 participants recruited, 18 had left, 16 had right and 6 had bilateral TKA surgery.

Ethics: This study was approved by the Bannatyne Campus Research Ethics Board In May 2013. Patients were included in the study if they were between 50 and 80 years of age, had just received elective TKA within the past 5-8 weeks and could read and understand the English language. After being informed of the purpose, risks and benefits, patients provided written consent. Patients were excluded if they had difficulty understanding the purpose of the study or were unable to provide consent (language barrier, cognitive impairment).

Experimental Design and Procedures

At the clinic, participants were provided with an ActiGraph GT3X+ activity monitor to wear on a belt around their waist at the anterior superior iliac spine in a vertical position while standing. An activPAL monitor was placed on the anterior thigh midway between the hip and knee joints using PAL*stickies*™ (double-sided hydro-gel adhesive pads). The activity monitors were worn on the non-surgical side (in unilateral total knee patients) and on the side that was first replaced in those with bilateral surgery.

Participants were directly observed for the entire duration of their follow-up visit unless they needed to use the change room or washroom, in which case, privacy was granted. A stopwatch was synchronized to the activity monitors prior to testing. All changes in posture and activity were recorded (in 5s time frames) during their appointment. During this visit to the Concordia Hip & Knee Institute, patients also completed the Oxford 12 Knee Questionnaire (48;49). Height and weight were measured using a standard floor scale/stadiometer (with shoes removed). Active range of motion of the involved knee(s) was measured with a goniometer. Participants were also timed as they completed a 10m walk at a comfortable speed and at a faster speed if they were able. Two repetitions of each speed were performed and an average speed determined. At the end of the follow-up visit, if participants were interested they were asked to continue to wear the ActiGraph GT3X+ monitor for 7 days as they went about their normal routine. They were given an addressed and postage paid Express Post envelope to return the monitor in the mail.

Data and Statistical Analyses: Physician Follow-up Appointment Data

ActiLife 6.11.1 software was used to initialize and download the ActiGraph monitors. Data was collected on 40 patients totalling 54,900 seconds (900minutes). Physician follow-up visit ActiGraph data was analyzed in 5 second epochs. ActivPAL ™ Professional Research Edition software (Version 5.9.1.1) was used to initialize and analyze activPAL accelerometer data. Data obtained from activPAL monitors was analyzed in 15 second epochs. Because of this difference in epoch length, ActiGraph data was later analyzed in 15 second epochs for comparison between monitors. Because of its placement on the thigh, the activPAL inclinometer is unable to distinguish between sitting and lying and instead separates output data into sedentary (sitting and/or lying) and upright (standing) postures. However, the ActiGraph separates data into the three categories of sitting, lying and standing. In order to compare the two monitors, the ActiGraph data had to be analyzed combing the sitting and lying data into one sedentary category. All downloaded data were converted to Microsoft excel spreadsheets for final data analysis.

The inclinometer function of both monitors was tested for its ability to accurately identify sedentary and upright postures in comparison to direct observation. SigmaPlot, Version 11.0 (Systat Software Inc., Chicago, IL) was used for statistical analyses. Accuracy [(Posture time correctly identified by the monitor / Actual Time in posture) X 100] and predictive value [(Posture time correctly identified by the monitor/total time the monitor detected posture) X 100] were determined for each patient and each of upright/standing for both monitors and sedentary (activPAL) and sitting/lying (ActiGraph). Paired t-tests (and Wilcoxon Signed Rank tests for non-normal data) were run to compare the accuracy and predictive values for the monitors. The participant data were then separated based on body mass index (BMI) classification (healthy, overweight, and obese). A series of two-way ANOVA tests with repeated measures were used to investigate between (BMI group) and within (device) factors, with accuracy and predictive value as dependent variables (each for both sedentary and upright postures). Post hoc pairwise comparisons were done with Tukey's test. Bland-Altman plots were also generated for each monitor for sedentary and upright postures to assess systematic bias and outliers(50).

Data analysis: **7 Day Data**

Data collected over seven days were analyzed using the ActiLife software (version 6.11.1). Wear time was first validated in order to exclude monitor off time from sedentary behaviour using the wear time validation tab provided with the software. Freedson Adult 1998 cut points were used in determining sedentary, moderate and vigorous activity intensities. Percent time in each physical activity intensity category using accepted acceleration cut-points; Sedentary (0-99), light (100-1951), moderate (1952-5724), vigorous (5725-9498) and very vigorous (9499 and above), was determined along with the absolute number of minutes after validating for wear time (51). Using the inclinometer data as provided from the ActiLife software, posture was analyzed. The software provides a breakdown of time spent in sedentary, light, moderate, vigorous and very vigorous activities as well as posture information. Figures 1 and 2 show sample graphs produced using the ActiLife software from one participant's seven day data. Using predetermined criteria for sedentary behavior analysis of at least 66 hours of total wear time or 5 days of at least 10 hours/day wear time (39;42;44;52), patient data were analyzed for sedentary behaviour and posture.

Results:

All 40 patients were included in the physician follow-up appointment data analysis. Patient function in activities of daily living was assessed using the Oxford knee score (mean score 35.53 +/- 7.25). Range of motion of affected knee(s) was measured with an average of 7.83° +/- 4.09° lacking in extension, and 96.67° +/- 18.62° of attainable flexion. Walking speed was only assessed in 37 patients as 3 were unable to complete the 10m test. Thirty patients were able to perform the walking test at both slow and fast paces. Average walking speed (slow/comfortable pace) was 1.04 +/- 0.09 m/s and the average fast pace was 1.16 +/- 0.27 m/s.

For the 40 patients, the activPAL showed significantly better accuracy in detecting both sedentary and upright postures (paired t-tests $p<0.05$). Accuracy for the ActiGraph and activPAL monitors in detecting sedentary postures was 58.4% and 89.9% respectively. Accuracy for upright postures was 54.3% for the ActiGraph monitor and 83.6% for the activPAL. Predictive values for sedentary postures were 92.8% for the ActiGraph and 99.9% for the activPAL. A significant difference was found for the sedentary predictive values ($p<0.05$) with the activPAL having a better predictive value. No significant difference was found between upright predictive values of 83.8% for activPAL as compared to 70.7% for the ActiGraph. Table 1 shows the accuracy and predictive values for sedentary and upright postures for both the ActiGraph and activPAL monitors for the 40 patients in the study. Bland Altman plots were also created in order to demonstrate the range of distribution of data (figures 3-6).

When analysed based on BMI classification (Table 2), there were 7 individuals in the healthy BMI range (18.4-24.9 kg/m^2), 13 overweight (25-29.9 kg/m^2) and 21 in the obese (30+ kg/m$^{2)}$ classification. The accuracy in detecting sedentary postures in the activPAL was 97.36%% as compared to the ActiGraph 43.9% in healthy participants. In the overweight population the activPAL was 97.57% accurate as compared to the ActiGraph accuracy of 46.3%. In the obese participants the ActiGraph accuracy mean was 72.22% and the activPAL accuracy was 82.55%. Analysis for the sedentary predictive value showed that in the healthy participants the activPAL had a mean sedentary predictive value of 99.47% as compared to the ActiGraph 81.17%. In the overweight population the activPAL predictive value was 99.89% as compared to the ActiGraph predictive value of 97.59%. The ActiGraph monitor showed a predictive value of 93.75% and the activPAL 100% in the obese participants. When analyzing for upright postures, in healthy participants the activPAL was more accurate 88.85% compared to the ActiGraph 64.32%. Overweight participant data showed activPAL upright accuracy of 85.05% as compared to 53.15% by the ActiGraph monitor. In the obese group the activPAL accuracy exceeded that of the ActiGraph monitor as well, 81.58% and 52.75% respectively. Upright predictive value in the healthy population was 91.88% for the activPAL and 55.92% for the ActiGraph. Upright predictive values in the overweight population were determined to be 95.85% and 81.3% in the activPAL and ActiGraph respectively. In the obese population these values were 72.57% for the activPAL and 68.91% for the ActiGraph.

Results of the repeated measures ANOVA tests indicated that in terms of sedentary accuracy there was a significant interaction between BMI and monitor type such that the activPAL demonstrated greater accuracy compared to the ActiGraph for the healthy and overweight groups ($p<0.05$). For upright posture accuracy, the interaction term was not significant. There was a main effect for monitor type demonstrating that the activPAL was more accurate than the ActiGraph monitor (for all groups, $p<0.05$). There was a significant interaction between BMI and monitor type for sedentary predictive value. The activPAL demonstrated greater predictive value than the ActiGraph for the healthy and obese groups. The ActiGraph monitor had greater predictive value in the overweight group compared to the healthy group ($p<0.05$). The interaction term was not significant for upright predictive value. There was a main effect for monitor type demonstrating that the activPAL had greater predictive value than the ActiGraph monitor (significant for the healthy BMI group, $p<0.05$).

Pilot data was collected over 7 days in 13 participants. Patients were instructed to wear the monitor during waking hours only. Three participants were excluded based on lack of wear time; less than 66 total hours or less than 5 days of 10 hours/day wear time time (39;42;44;52) .

The remaining 10 participants had a mean wear time of 83 hours, 36 minutes and 47 seconds (5016.78 +/- 442.78 minutes). This equated to an average of 44.5% wear time over the seven days. On average patients spent 73.36% (+/- 10.77 %) of total monitor wear time in sedentary behaviours. In evaluating postural activity over the seven days, patients spent on average 28.93 hours (34.61%) of their wear time in standing, 45.52 hours (54.45%) in sitting and 9.64 hours (11.53%) in lying. This translated to patients spending on average 4.13 hours/day in standing, 6.50 hours/day in sitting and 1.38 hours/day in lying. Participants in this study spent an average of 0.46 hours (1.92%) in moderate to vigorous physical activity per day. Participants spent 73.36% of their wear time in sedentary behaviours and 22.01% in light intensity activities.

DISCUSSION

The activPAL and ActiGraph are very popular tools used in current research measuring physical activity and sedentary behaviour. Their use makes studying physical activity and sedentary behaviour increasingly more accurate and efficient (11;15;41-43;45;53). The ActiGraph, has been analysed for its accuracy in recording various sedentary and light-intensity activities in healthy subjects (11). Both the ActiGraph and activPAL were validated in a study specifically looking at sedentary behaviour (42). Unfortunately, there is a gap in the literature as to how accurate these monitors are in people with mobility issues and increased body mass index. Many studies have validated these monitors in what they term “typical” adult populations (4;13;17;40-42;44;45;53), which generally refer to healthy adults without known medical conditions. Studies which have looked at physical activity levels in patients after total knee arthroplasty (14;36;37;54-57) have most often used self-administered questionnaires to obtain their data, and these can often be inaccurate due to various factors such as broad summarizations, timing of filling out the questionnaire, interpretation of questions, recall bias and the tendency to report good outcomes(13;58;59).

Over the 40 patients in this study, the activPAL showed significantly better accuracy compared to the ActiGraph in detecting both sedentary and upright measurements (paired T-Tests p<0.05). A significant difference was also found for the sedentary predictive values (p<0.05), which were 92.8% for the ActiGraph and 99.9% for the activPAL. No significant difference was found between upright predictive values of 83.8% for the activPAL as compared to 70.7% for the ActiGraph. Predictive value of the monitors is perhaps the more important value as it determines whether or not we can trust the output data. Accuracy only takes into consideration correctly identified postures, whereas the predictive value includes how often the monitors detected a posture incorrectly, for example indicating that an individual is standing when they were actually sitting. Generally, the results may be explained by the position of the two monitors. The activPAL, being positioned on the anterior thigh, is unable to distinguish between sitting and lying and combines those postures into a sedentary category. The difference in incline angle between sedentary and upright is quite large and hence, the monitor is expected to be rather accurate in distinguishing between the two. The ActiGraph monitor provides two types of information; physical activity intensity (activity count) measurements and inclinometer information. Both types of information are used to determine posture and increase accuracy of the monitor. The position of the ActiGraph on the hip may contribute to discrepancies in sitting and standing where the angle of incline may not always differ to a significant extent, especially if an individual sits very upright. This was often a discrepancy noted with the GTX3+.

On average patients in this study spent 73.36% (+/- 10.77 %) of monitor wear time in sedentary behaviours. This is more than the amount of sedentary behaviour in adults >60 years of age, which previous studies have concluded to be <66% of waking hours (4-8;40). In evaluating postural activity, patients spent on average 6.50 hours/day in sitting, 1.38 hours/day in lying and 4.13 hours/day in standing. When compared to established values for adults >60 years of age the amount of time spent standing was less than the typical 9.1 hours/day (40;60). A number of studies have shown that older adults typically spend <60-66% of their waking hours in sedentary behaviours, 30-34% in light intensity and 2-4% in moderate to vigorous intensity physical activity (5;7;15;40;45). Faisal (2013), using the ActiGraph GTX3+, showed that a typical 24 hour cycle in older adults consists of 31.25% (7.5 hours) of sleep 39.17% (9.4 hours) in sedentary behaviours, 27.08% (6.5 hours) of light intensity activity and 3.13% (0.75 hours) of moderate to vigorous physical activity. In terms of waking hours, this translates to 56.97% in sedentary behaviour, 39.39% in light intensity and 4.55% in moderate to vigorous intensity activity (40). Because patients were instructed to take off the monitors at bed time, time spent sleeping was not assessed in our study. Participants in this study spent a much greater percentage of waking hours in sedentary behaviours; 73.36% and less time in both light intensity; 22.01% and moderate to vigorous intensity; 1.92%. Participants in this study spent far less time in moderate to vigorous physical activity per day than the typical older adult, less time in light intensity activity, and far more time engaged in sedentary behaviour, suggesting that at 5-8 weeks post TKA, patients still have some limitations in terms of physical activity.

Evaluation of the increased amount of sedentary time along with a reduction in standing and in hours of moderate to vigorous physical activity, suggest that patient views on reduction in pain and increase in function has not yet translated to increased activity at 5-8 weeks post TKA. Subjective evaluations of pain and function are often analysed using the Oxford knee questionnaire (60). This questionnaire allocates a score of 1 for the least limited response, such as no pain and 5 for the most severe such as impossible to do. The score is generally reported out of 60 with a lowest/best score possible of 12. What constitutes a good score is based on clinical experience. Studies have shown that an average pre-op score is 44 and at 6 month follow-up the score is reduced to 29, indicating improved patient pain and function (60-62). The 40 participants in this study had a mean Oxford knee Score of 35.53 suggesting that some improvement in pain and function occurs by 5-8 weeks post TKA. Objective studies such as this, have determined that on average patient physical activity levels often do not return to normal age expected levels after total knee arthroplasty. Although large improvements may be seen in pain and patient perceived function, improvement in actual physical activity is less than expected (25-28;36;37;56;57;63). The limitations in range of motion of the knee may play a role. The mean flexion arc in this study was 7.83°-100.94°. Functional range of motion at the knee is different for various activities; inclines require less than 90 degrees of knee flexion, stairs and chairs 90-120 degrees of flexion and a bath approximately 135 degrees of flexion (64). At 5-8 weeks post-op, some patients may still lack significant range of motion in the knee for various activities of daily living.

Time spent in activities requiring low levels of energy expenditure have been linked to various adverse effects on health including weight gain, cardiovascular effects and type 2 diabetes (2;4;10;63;65-67). Increased sedentary behaviours are seen in individuals who are overweight as well as those with mobility issues. Patients awaiting TKA fall into both categories. Often the prolonged wait time for elective surgery can compound the effects of increased BMI and inability to participate in physical activity due to pain and decreased function. Considering that 85% of patients in this study fell into the overweight and obese categories of BMI, this patient group was already at an increased risk of adverse health effects. A year of primarily sedentary behaviour while waiting for surgery not only has adverse effects on health, but also often leads to habitual sedentary behaviours which do not change post TKA (14;37;55;63;68;69).

Strengths of this study include the use of an objective measurement of overall sedentary behaviors. Accelerometer cut point selection was based on a validation study in adults(51). An additional strength of our study was patient compliance with the measurement procedures. 77% of patients who agreed to take home the ActiGraph monitor for 7 days were able to be included in data analysis based on established requirements of 66 hours total wear time or 5 days of 10 hours/day (19;38-40;42;44;52). This suggests that our methods provide useful estimates of the population mean for amount of time spent in sedentary behavior in patients 5-8 weeks post TKA.

Limitations of our study should also be considered. The assessment of sedentary behaviours using accelerometers is relatively new and our estimates of time spent in these behaviors are sensitive to the cut points employed. The small sample size in our seven day data (n=10) must also be taken into consideration as any values that were extreme (low sedentary or very high sedentary) may skew the data in such a small sample size.

Conclusions:

In conclusion, both the activPAL and ActiGraph monitors are effective tools for measuring sedentary behaviours, however the activPAL has a significantly better profile when body mass index is taken into consideration. Many healthy older adults spend the majority of their waking time in sedentary behaviors, however patients post total knee arthroplasty, spend even more time being sedentary.

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Appendix: List of Figures

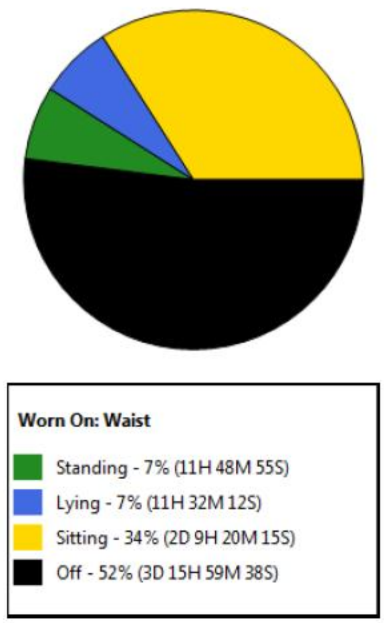

Figure 1: Inclinometer data Example pie chart generated from ActiGraph software demonstrating percentage of time spent in different postures over the seven day period (from representative participant).

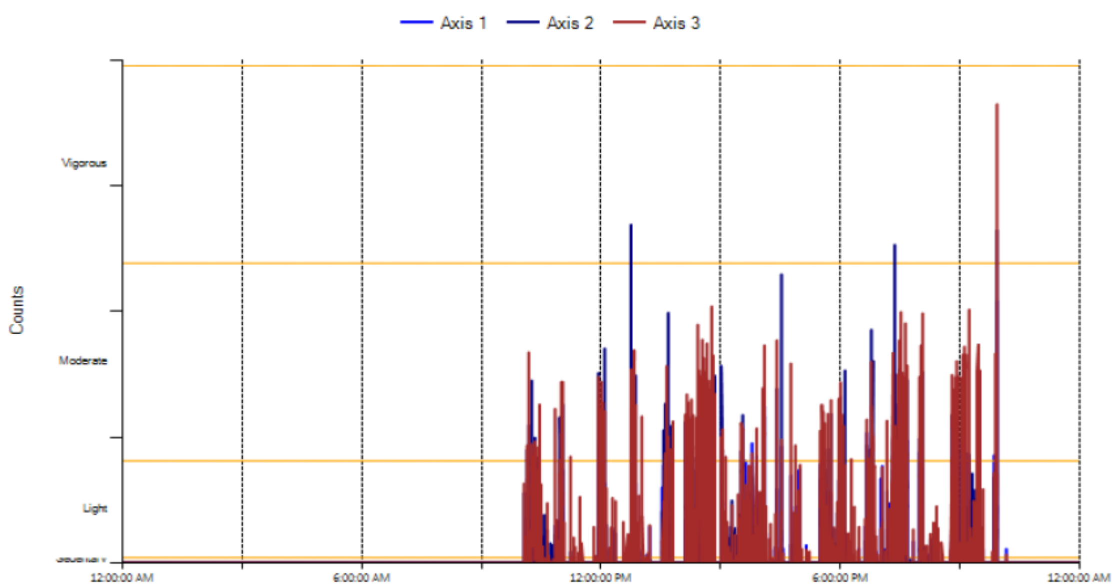

Figure 2: Accelerometer activity count data
Example plot generated from ActiGraph software demonstrating activity counts over one day (for representative participant). Based upon Freedson 1998 cut points, accelerometer data determines the amount of time spent in sedentary, light, moderate, vigorous and very vigorous activity.

	activPAL Sedentary		ActiGraph Sedentary	
	Average Accuracy	***Average Predictive Value***	***Average Accuracy***	***Average Predictive Value***
40 Patients	89.9 % (SD 23.9%)	99.9% (SD 0.6)	58.4%* (SD 32.3)	92.8% (SD 13.1)
	activPAL Upright		**ActiGraph Upright**	
	Average Accuracy	***Average Predictive Value***	***Average Accuracy***	***Average Predictive Value***
40 Patients	83.6% (SD21.4%)	83.8% (SD 30.0)	54.3%* (SD 32.3)	70.7% (SD 38.9)

Table 1: Comparison of activPAL and ActiGraph Accelerometer Data for Detecting Sedentary and Upright Postures. *indicates significant difference (Paired T-test, p<0.05)

			BMI Mean +/- Standard deviation (%)					
			Healthy n=7	**Overweight n=13**	**Obese n=21**	**BMI**	**Device**	**BMI X Device**
Sedentary	***Accuracy***	activPAL	97.36 +/-3.04	97.57 +/- 2.50	82.55 +/- 30.41	0.658	<0.001*	0.004*
		ActiGraph	43.9 +/- 37.86	46.3 +/- 33.92	72.22 +/- 24.98			
	Predictive Value	activPAL	99.47 +/-1.51	99.89 +/-0.26	100 +/- 0	0.021*	<0.001*	0.022*
		ActiGraph	81.17 +/-26.25	97.59 +/- 2.92	93.75 +/- 5.94			
Upright	***Accuracy***	activPAL	88.85 +/10.53	85.05 +/- 8.86	81.58 +/- 29.17	0.648	<0.001*	0.954
		ActiGraph	64.32 +/-20.93	53.15 +/- 24.71	52.75 +/-31.36			
	Predictive Value	activPAL	91.88 +/-3.78	95.85 +/-13.01	72.57 +/-37.01	0.139	0.03*	0.18
		ActiGraph	55.92 +/-43.45	81.3 +/-35.51	68.91 +/-39.84			

Table 2: ANOVA analysis investigating differences in 4 outcomes with respect to device used and Body Mass Index (BMI). Post hoc pairwise comparisons were done with Tukey's test. * indicates a significant difference (p<0.05)

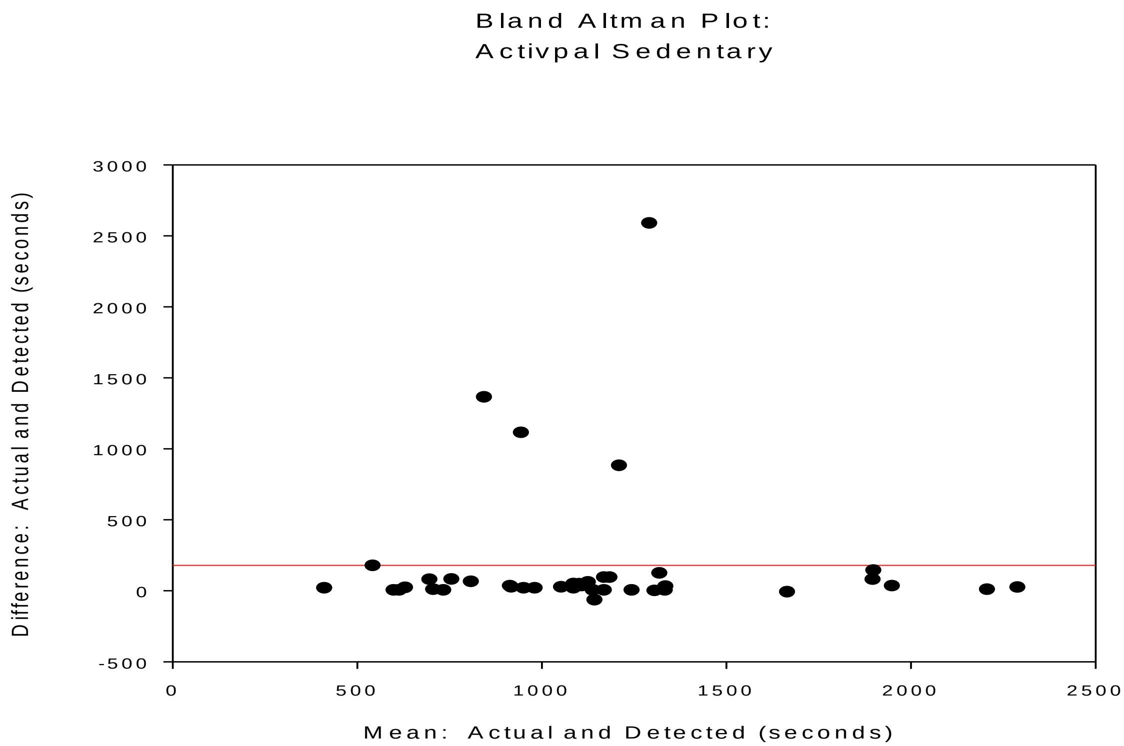

Figure 3: Bland Altman plot of activPAL detected sedentary posture

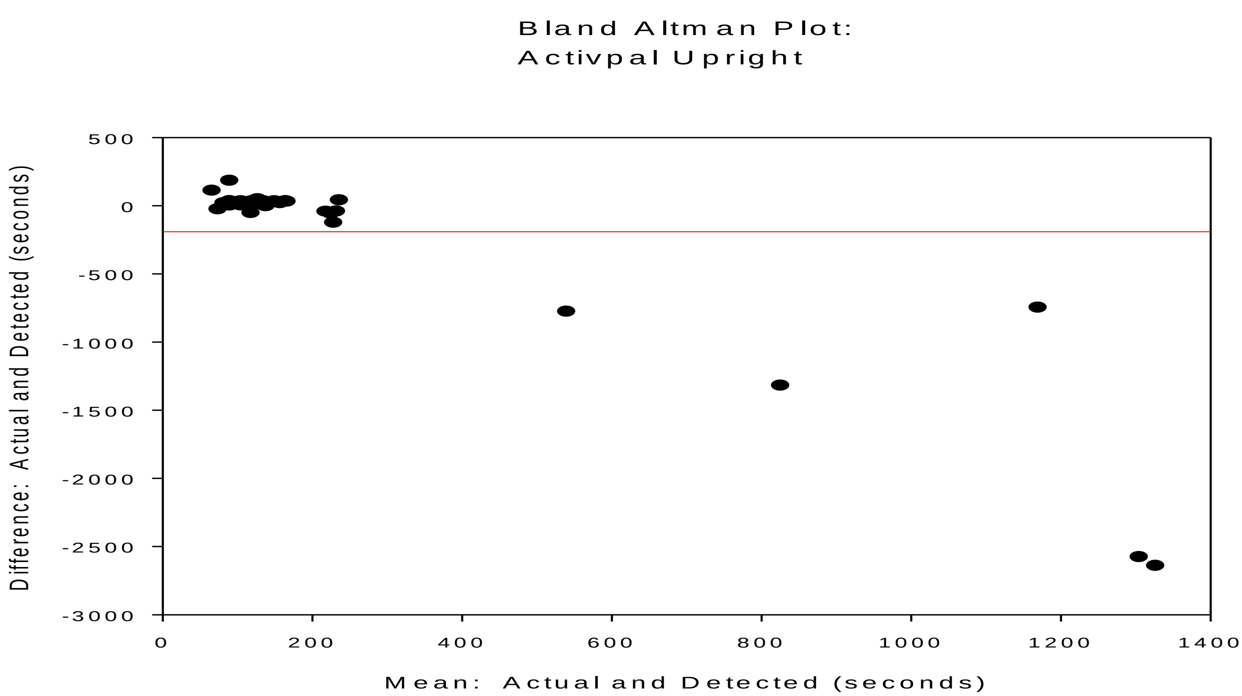

Figure 4: Bland Altman plot of activPAL detected upright posture

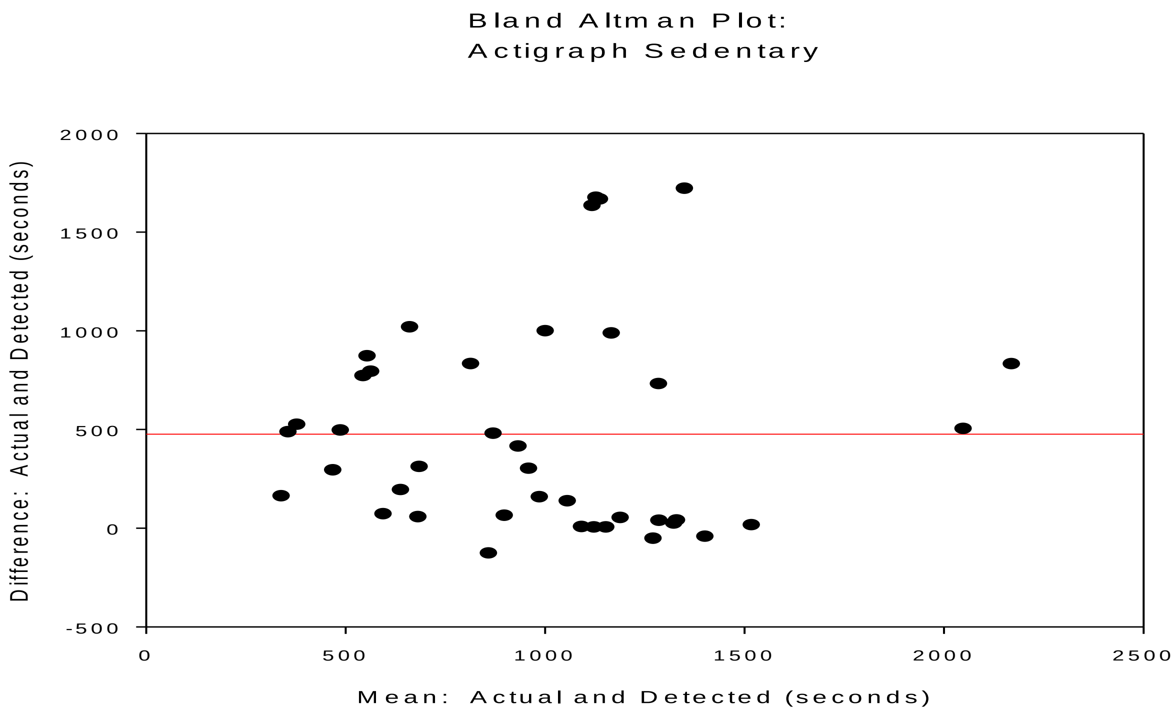

Figure 5: Bland Altman plot of ActiGraph detected sedentary posture

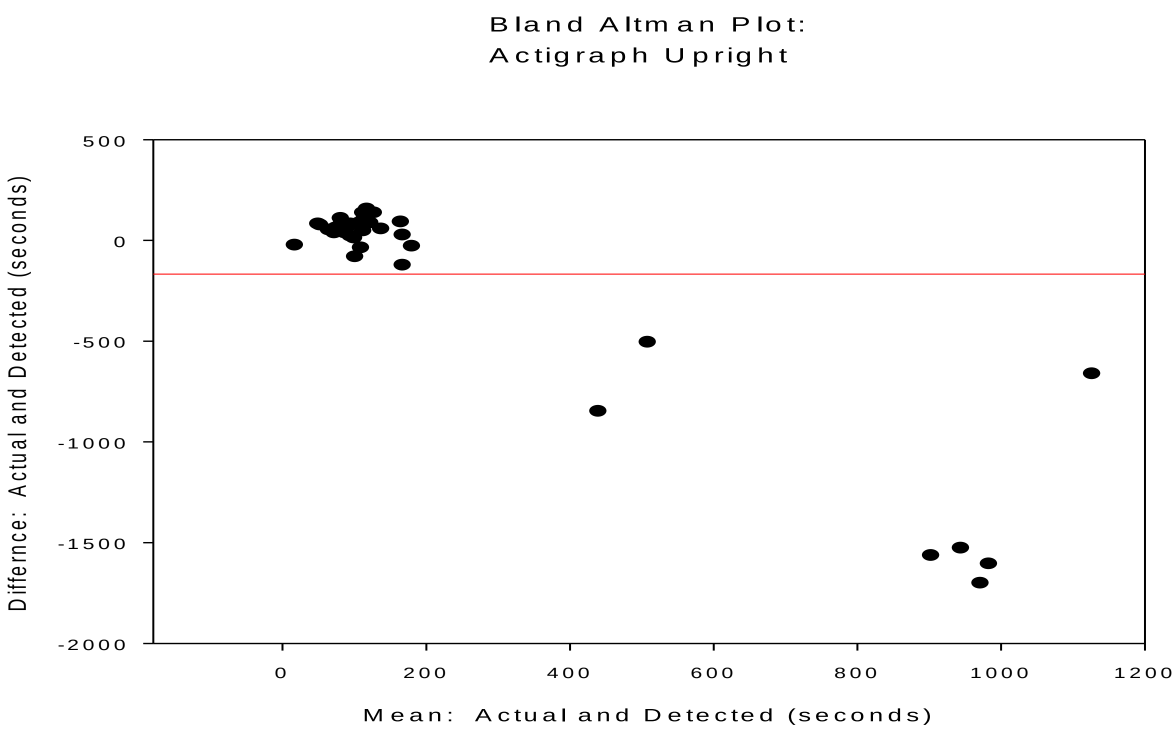

Figure 6: Bland Altman plot of ActiGraph detected upright posture