

Technical Note

Method for objective assessment of physical work load at the workplace

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This report presents a method for objective assessment of physical work load at the workplace. The method is based on the DynaPort ADL monitor. Using accelerometry this monitor enables the assessment of gross motor activity as it occurs during the activities of daily living (ADL). A case study is conducted to explore the usefulness of the monitor in support of occupational research. The focus is on provocations and reductions of mechanical low back pain (LBP). A patient suffering from mechanical LBP participated in the study. The patient's normal occupation was maintenance mechanic. The patient was set to work as messenger whereas this job was presumed to be less physically demanding, and therefore to be less provocative for LBP. The patient was examined in both occupations using the DynaPort ADL Monitor. The ADL profiles differed substantially from the expectations of the patient's medical executives. The occupation of messenger was concluded to be more provocative for LBP than the occupation of mechanic because it lacked activity variation, and included much walking activity and standing posture combined with flexion movement. The patient's therapists recommendation was based on these results, and accordingly the patient returned to work in his normal occupation of maintenance mechanic.

1. Introduction

The relationship of low-back pain (LBP) to work history and work environment factors is often debated. Variables that are found to be correlated to the occurrence of LBP are; less overtime work, diminished work satisfaction, decreased potential to influence the work situation, lesser demand on concentration, monotonous work, physically heavy work, a high degree of lifting, to a lesser degree sitting, and to a greater degree of standing and walking work posture (Svensson and Andersson, 1983). In a more recent study, Lindström et al. (1994) found that the correlations between LBP and reported or observed physical work demands, as well as other factors are not clear. Still, more than 60% of the patients in this

study believed that work demands caused their LBP. Partly the debate may result from a difference between patients suffering from mechanical LBP and LBP patients suffering from neurogenic compression; the first experiencing that the pain directly relates to physical work load.

Through ambulatory monitoring, the DynaPort ADL monitor enables assessment of gross motor activity as it occurs during the activities of daily living (ADL). Using accelerometry this monitor can analyse many aspects of posture and activity as well (Veltink et al., 1994; Busmann et al., 1995; Veltink et al., 1996). A case study is conducted to explore the usefulness of the monitor for support in occupational research. The physical work load is studied in terms of provocations and reductions of LBP.

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This study describes how the DynaPort ADL monitor was used (1) to record the physical activities of occupation in terms of posture, cyclic movement, a-cyclic movement, and frequency and variability of their occurrence, (2) to evaluate the usefulness of activity parameters for support in the assessment of occupational LBP patients that are to return to work, and (3) to get an understanding of the factors that contribute to physical work load of an occupation.

2. Methods

2.1. Patient

A patient with chronic LBP participated in this study. He has mechanical LBP with extensive degenerative disease of the lumbar spine.

2.2. Procedure

On two consecutive days the subject's activities were registered. On day one the subject performed a maintenance mechanic job, on day two a messenger job. Both days the physical work load was representative for the occupations. The subject and his two examiners met at 8:00 am at the work-place. One examiner applied the DynaPort system to the subject, the second video filmed the subject's activities. During the coffee break the video was shut off. The occupational activities lasted until noon (12:00 am).

2.3. Job Descriptions

The activities of the maintenance mechanic constituted of maintenance and repair jobs of domestic central heating installations (CHI). In a work day of four hours, the subject worked on five CHIs. Between jobs the subject was driving a car to get from one site to the other. The working postures and activities included

kneeling, standing, wobbling and walking. Lifting tasks were occasional. There was a coffee break halfway.

The activities of the messenger comprised sorting mail, prepaying postage and distributing mail. All activities took place at city hall. The working postures and activities included standing, wobbling, short tracks of walking, pushing the mail carrier, handling mail and bending. Lifting tasks were occasional. There was a coffee break halfway.

2.4. Data Acquisition

Data was acquired with the DynaPort ADL monitor, a measurement and analysis system containing compact and lightweight measuring and storage equipment. It was mounted on a belt worn around the waist inconspicuously with everyday clothing, with a sensor in a strap mounted on the upper leg underneath clothing (Fig. 1). Using accelerometry the ADL monitor electronically logs the motor activities of daily living. Digital data is analysed continuously and expressed in terms of body posture (like lying down, sitting or standing), cyclic activity (such as walking or bicycling) and movement parameters (such as movement intensity and frequency). With the recordings all activities were video filmed.

2.5. Reliability Assessment

The ADL monitor's performance compared to video observation yielded good results with minimal and maximal validity percentages between 89 and 96.5%. Minimal and maximal validity percentages reflect instantaneous agreement (moment by moment) and overall agreement respectively (Uiterwaal et al., 1998).

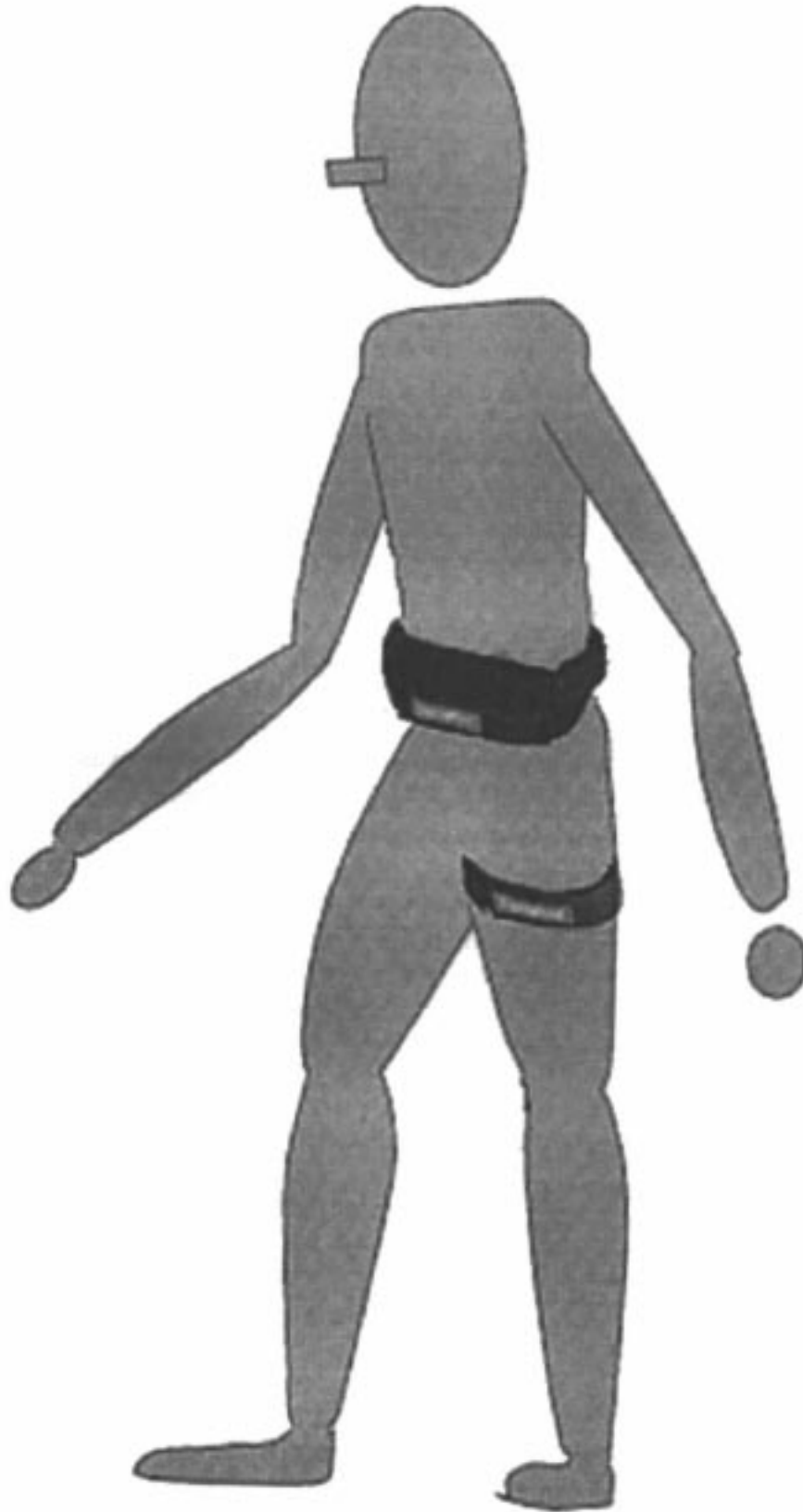


Figure 1. Dynaport measuring and storage equipment was mounted on a belt and worn around the waist inconspicuously with everyday clothing, with a sensor in a strap mounted on the upper leg underneath clothing.

2.6. Pain Ratings

About every thirty minutes, the patient rated his back pain on a visual analogue scale (VAS) from 1 to 10; 1 being not painful at all, 10 being very painful. The time of the rating was marked in the activity recordings by pressing a button on the DynaPort recorder. The recorder displayed the serial number of the rating and the patient wrote down this number along with the pain rating on a paper form.

2.7. Data Treatment

The data was stored on a PC-Card and afterwards read out on a personal computer. The data were automatically classified by the ADL monitor software every second in one of four categories; locomotion, standing, sitting, and lying. The numbered VAS rating marks were listed by the software interface and the VAS ratings were manually entered into the computer. ADL outcomes, movement features and class statistics were calculated every 10 minutes and overall. The overall physical activity was calculated and expressed on a level from 0 to 6; 0 representing inactivity as in lying quietly; 3 representing walking at a moderate pace; and 6 representing high activity as in jogging. The periods in which more than 50% of the time lying or sitting was classified were indicated as resting periods. The differences between the recordings were evaluated by means of exploration. Based on these results the physical work load of the two occupational conditions was assessed.

3. Results

3.1. Activity Distribution

The activity distribution is evaluated by means of the distribution of the main activities of daily living as grouped in the categories locomotion, standing, sitting and lying (figures 2a and 2b). The incidence of these classes was 23.9, 41.4, 30.3 and 1.6% respectively for the messenger job, and 15.3, 36.5, 47.4 and 0.2% respectively

for maintenance mechanic job. In the messenger job 65.3% percent of time included standing and walking activity, opposed to 51.8% in the mechanic job. In the first two hours of the messenger job there was no resting time at all. There was a short period of lying in the messenger job as the subject was performing a repair job. The overall physical activity was higher in the messenger job (1.82 ± 0.51 std.) than in the mechanic job (1.61 ± 0.38 std.).

3.2. Pain Ratings

On both days 9 ratings were recorded. The median pain ratings 5.0 for the mechanic job and 6.0 for the messenger job. Pain was inclined to rise with an increase in physical activity and was inclined to decrease in resting time (figures 3a and 3b).

3.3. Reductions of LBP

Reduction of LBP was achieved by variation of periods standing and walking with sitting. There were less occasions for sitting during the messenger job than in the maintenance mechanic job 2 periods of resting in the messenger job opposed to 4 in the mechanic job (figures 3a and 3b), adding up to 58 and 100 minutes of sitting resp.

3.4. Causation of LBP

Causation factors of LBP were regarded to a lack of activity variability and static loading. A lack of variability in activity is apparent in the messenger job compared to the maintenance mechanic job. Large flexions of the trunk (of more than 50°) were observed more frequently in the messenger job (43) compared to the maintenance mechanic job (22) (fig. 4). Of standing posture, more standing in a flexed posture was observed in the mechanic job (75 minutes total, 36% of the time standing) than in the messenger job (79 minutes total, 17% of the time standing).

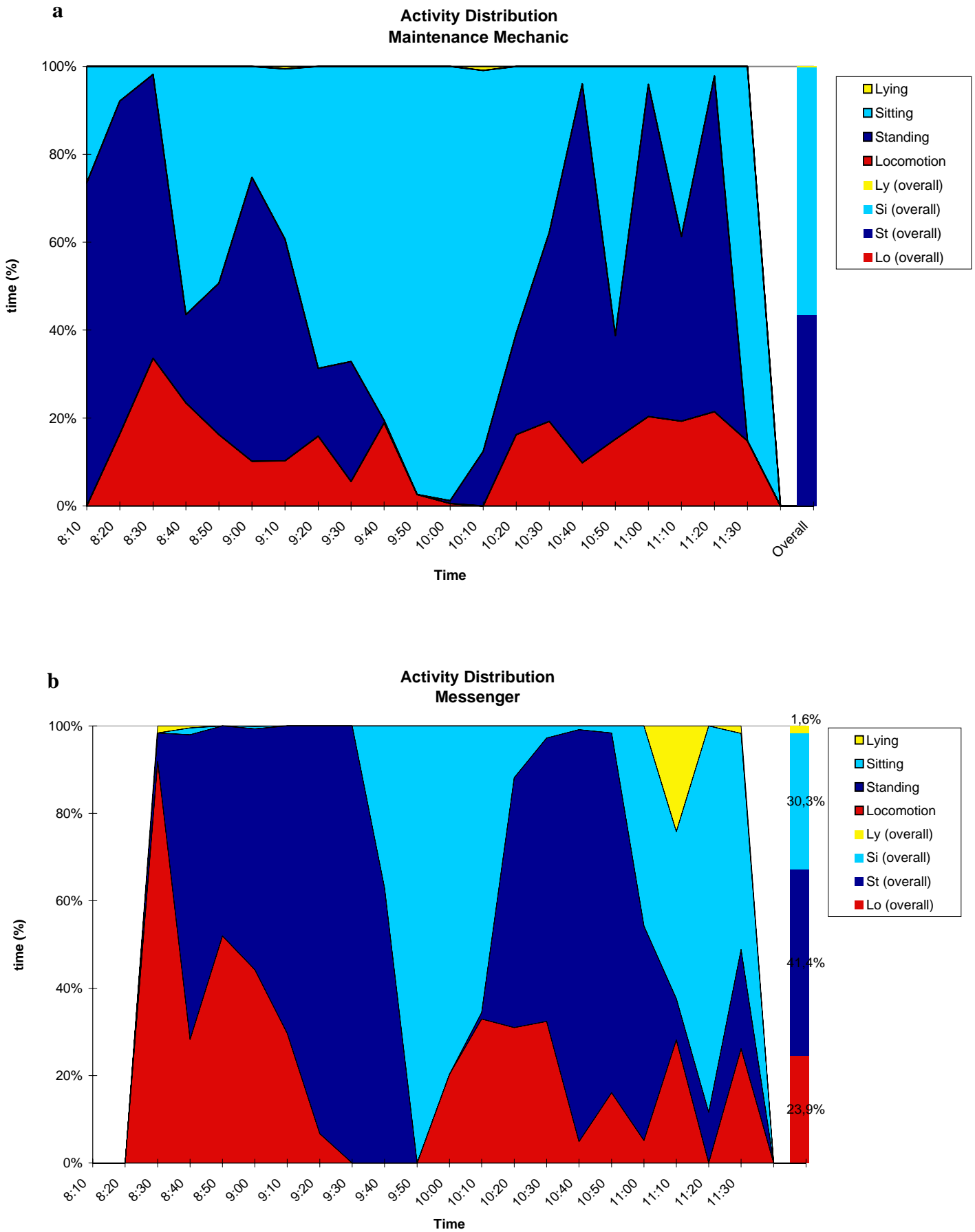


Figure 2. Activity distribution of the main ADL categories; locomotion, standing, sitting, and lying over time during the messenger job (a) and the maintenance mechanic job (b). On the y-axis the per cent of time per 10-min interval is subdivided in these four classes. The overall percentages are shown in the rightmost bar.



Figure 3. Physical activity, rest periods and pain rating on a VAS during the maintenance mechanic job (a) and the messenger job (b). The average pain rating is shown in the rightmost bar.

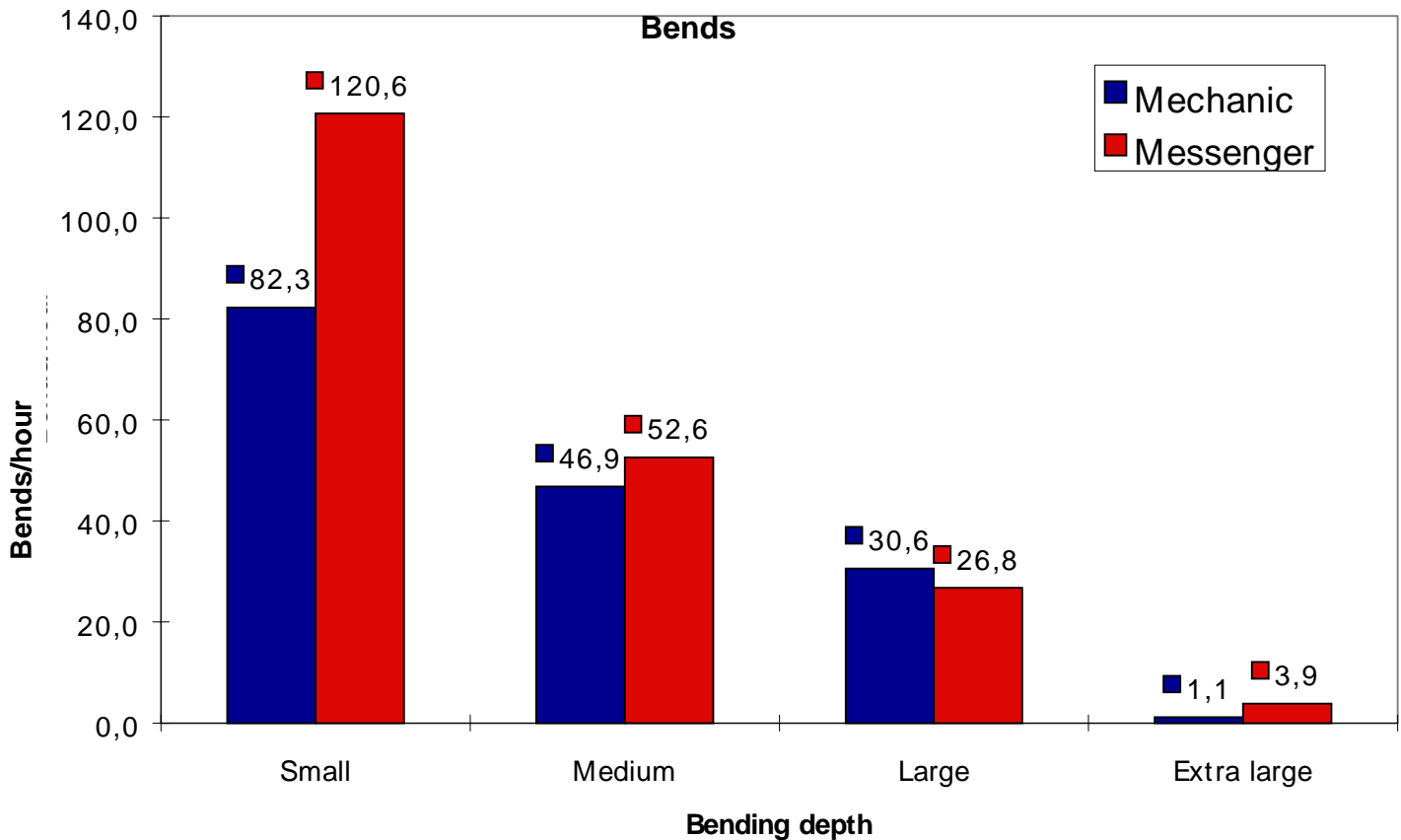


Figure 4. Bends during standing posture for both the messenger and mechanic job. The average number of bends per h is shown for four categories of bends: small, medium, large and extra large.

4. Discussion

4.1. Physical Work Load of two jobs: Messenger vs. Mechanic

The physical work loads of both maintenance mechanic and messenger were provocative for LBP in the patient studied. In this respect, the jobs appeared more similar than was expected beforehand. A priori, it was expected that static loading of the back would be observed in the messenger job due to sustained periods of sitting. Based on prior clinical assessment and muscle function measurements this was expected to be provocative for LBP. Based on the observed activity distribution it may be concluded however that the sustained loading as provocation was due to the periods of standing and walking. Also more bending as observed in the messenger job was concluded to be provocative for LBP. The maintenance mechanic job was more variable in respect of physical activity, allowed for more variation of periods of standing, walking and sitting, and in that

way allowed for reduction of LBP. The sitting during road transport in-between jobs contributed to this. Based on these results we conclude that the physical work load of the maintenance mechanic job was less than that of the messenger job.

4.2. Physical Work Load Assessment Using ADL Monitoring

The activity profile and work load of the occupation of messenger differed from the assumptions that the medical executives had in mind prior to the measurements. Because the ADL Monitor showed a more apt picture of the jobs without the need for visual observation, we conclude that the ADL monitor can assist adequately in job and patient assessment. The ADL monitor supplies objective data that depicts physical work loads that may provoke LBP, as well as physical activity aspects that may reduce LBP.

4.3. Pain Progression

The pain ratings of the subject were correlated to the activity measures in the messenger job. This correlation is less specific in the maintenance mechanic job, although the pain appears to stabilise during road transport. The subject noted that there was a difference in pain on day 1 and day 2, in this case partly due to the quality of sleep during the night before. The day the subject worked as maintenance mechanic he notified to have started off 'worse'. To get a grip on day to day differences and progression of pain across the 24 hr it could be advantageous to monitor the night before, and the rest of the day-time after work. It's relations to activity can be explored for an even more competent assessment.

4.4. Pain Progression and Work-Rest Cycles

The clinical use of 'up-time,' defined as either the amount of time spent out of bed, standing or walking has been documented as a dependent measure with chronic LBP patients (Sanders, 1983). In occupational research a similar measure may help in the assessment of work-rest cycles. Assessment of such rest-periods may also help in job improvement.

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