Body worn video cameras with simultaneous technical measurements for ergonomic assessment of full work days

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Abstract. Video is a powerful tool in ergonomic observations. However it is often time consuming to record a video and to identify demanding work postures. A time-saving method was developed: information from direct measurements synchronized with video of a body worn video camera was utilized to identify reasons for demanding work moments. This method was successfully tested on a 5.5-hour work shift of a garbage collector: 17 of 18 events when the worker bended forward were quickly identified in a video editing software with guidance of inclination data (inserted as an audio track) from an accelerometer attached to the worker's back.

Keywords. Video, Physical load, Observation methods, Technical measurements

1. Introduction

Video is a powerful tool in ergonomic assessments (Forsman et al., 2003; Spielholz, et al., 2001). However it can be time consuming to do analyses of video recordings (Mathiassen et al., 2012; Rezagholi et al., 2012) Video recordings are also often limited to a short episode of the workday and the result of the observation therefore depends on the time of the recording. Important information with interesting events at work can then be missed (Van Eerd et al., 2009). To follow a person for a whole workday with a video camera is certainly time-consuming, and in many situations it is even impossible. Other technical equipment for direct measurements of responses related to work activities for example heart rate, postures or muscle activity can be worn a whole workday. However, direct measurements alone cannot tell the researcher or practitioner the reason for a specific movement, increased heart rate or muscle activity. Neither can it tell during which task that is occurring. By combining direct measurements with videos one can identify and analyze the tasks and activities at work that leads to a physiological response or specific demanding situation. Nowadays there are body worn video cameras that according to the manufacturer have the ability to record 8 hours continuously. One solution for ergonomic assessment or task analysis could then be to use these body worn video cameras together with direct measurement. The information from the direct measurements could then guide the observer to interesting parts of the recorded video of the workday.

The aims of the study were (1) to develop an easy-to-use method to utilize information from direct measurements synchronized with a body worn video camera to identify demanding work moments, and (2) to test this method by using a low cost accelerometer on the back of a garbage collector and find out the reasons for all his forward back bendings during a whole work day.

2. Methods

2.1 Equipment

Two cameras (RS3-SX, Reveal media, London, Great Britain; with an additional battery pack) were used. The first camera was attached to the garbage collectors chest with a harness (figure 1). To identify if there were events that could not be identified with the body worn camera the second camera was mounted on a car that followed the garbage truck. A tri-axial USB accelerometer to measure back inclination (X8M-3mini, Gulf Coast Data Concepts, Waveland, MS, USA) was attached with double-coated adhesive tape to the upper back.

Figure 1. The body worn camera attached with a harness

2.2 Procedure for synchronization of video and inclination data

A clear master clock on a smartphone (Android app "studio clock") was recorded with both cameras in the beginning and end of the work shift. Before the work shift the garbage collector stand for 5 seconds in a neutral posture focusing on a distant point in eye-height, and directly thereafter made three forward bendings and three jumps that were recorded both with the cameras and the accelerometer. The neutral posture was found automatically (through identification of the 3 bending, and all accelerometer data was converted to forward/backward inclination. After the work shift the video files were imported to the video editing software Sony Vegas Pro 12.0 (Palm, et al., 2013). With guidance of the recorded time in the videos, the video sequence could be synchronized correctly to the timeline in the video editing software. The recorded videos were automatically divided into several files by the cameras and for every new file there were some video frames that were missing. This caused a drift in relation to the master clock that had to be adjusted for by adding some extra frames in between the videofiles. The inclination data were converted to a *.wav file (sound file) in MATLAB 7.1 (MathWorks Inc., Natick, MA, USA). This made it possible to import the inclination data to the audio track in Sony Vegas Pro (Sony Creative Software Inc., figure 2). The test bending and jumps in the beginning of the video were identified visually in the inclination waveform. With guidance of this the inclination data could be synchronized with the video file by sliding the file in position at the timeline.

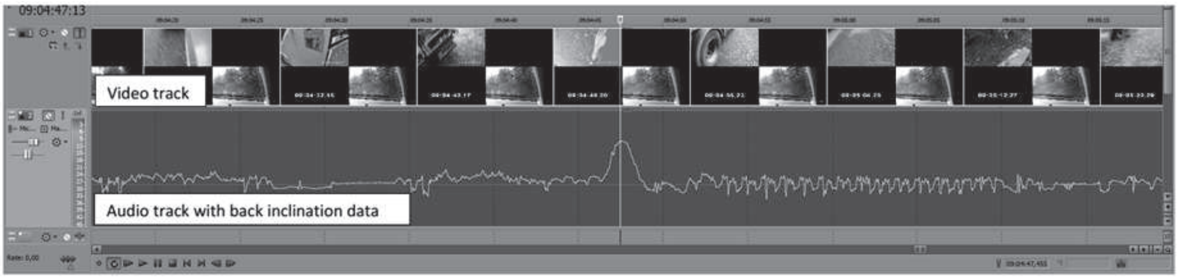

Figure 2. Back inclination data visualized on the audio track in Sony Vegas Pro

2.3 Assessment of video

An ergonomist visually screened the waveform from the inclination file in the audio track of the video editing software for events that showed forward bending (figure 2). When an event was identified the ergonomist zoomed into the timeline and watched a 10 seconds long sequence adjacent to that event. The time that ergonomist used for this was registered.

3. Results

The whole work shift was recorded (5.5 hours). During this time all events when the worker were bending forward was identified (n=17). In 11 of these events the worker were bending to pick up small pieces of litter that were dropped on the ground. Two times the worker were leaning towards cars to chat with the drivers. The other events were when the worker; took on his shoes in the morning; moved a watering can that were in the way for the garbage container; raised up a garbage container that was tumbled over, and when the worker were leaning towards the locker in the dressing room at the end of the work shift. All but one reason for the forward bendings could be identified with the body worn camera. In the one exception, the view of the video camera did not reveal the actual reason. The reason for that event, was that the worker was picking up litter from the ground, which was identified with the camera that was mounted on the car that followed the worker.

When the data and movie had been synchronized, it took about 15 minutes to visually screen through the 5.5 hours of accelerometer data in Sony Vegas Pro and to identify and find out the reasons for the forward bending for all these events.

4. Discussion

In this pilot study a quick and feasible method to identify the reasons for specific physical demanding events in a workday was developed and successfully tested by using a body worn camera synchronized with technical measurements in commercial video editing software. In the example the reasons for forward bending was analysed by registering back inclination with a low cost accelerometer.

Combination of video and technical data have been used before in ergonomic assessments (Forsman, et al., 2002; Rosén et al., 2005) but the use of commercial video editing software to visualize the waveform of the back inclination data made it possible to easily navigate through the 5.5 hours long video and data sequence and quickly identify all forward bending events.

There was an issue with the camera that dropped some frames that caused a drift. This needed to be adjusted for manually. With another camera this might not be a problem.

Due to privacy reasons it can be problematic to register video from a whole workday.. It was not possible to stop the recording during the day because this would have affected the synchronization of the video with the technical measurement. In this study the privacy problem was solved by the worker putting on a lens cover when he did not want the camera to register what he was doing. Also, the microphone was turned off for the whole recording.

A body worn camera captures a view from the person wearing it. Therefore it is not suitable to use for assessment of body postures. But it is useful when identifying the tasks the person is doing.

Both practitioners and researchers are in need of cost effective methods for observation of work. Earlier studies have demonstrated a cost effective method to analyze series of extracted still pictures from a video sequence instead of assessing sequences of moving videos (Rezagholi m.fl., 2012). This method can be useful in analyzing the proportion of time something is occurring but is not a useful method to assess frequency of events. For this purpose the presented method would likely be a better alternative to use. Without guidance of technical registration the alternative would have been to scan fast-forward through the whole video sequence, but then it would probably be easy to miss important events.

The presented method has a potential to be used in many different situations as any time series data can be converted and imported to the video editing software. Possible fields of use are in occupational hygiene, behavioral studies, risk assessment etc. Examples of other types of use could be: quality control and validation of large amount of data; to find out the best target for a work place intervention, by finding, as in the example used here the reasons for specific exposures.

5. Conclusion

Synchronizing technical data and body worn videos in a commercial video editing software can be a feasible and quick way to do ergonomic assessment of many hours of work.

References

Van Eerd, D., Hogg-Johnson, S., Mazumder, A., Cole, D., Wells, R., & Moore, A. (2009). Task exposures in an office environment: a comparison of methods. Ergonomics, 52, 1248–1258.

Forsman, M., Hansson, G. A., Medbo, L., Asterland, P., & Engstrom, T. (2002). A method for evaluation of manual work using synchronised video recordings and physiological measurements. Applied Ergonomics, 33, 533–540.

Forsman, M., Pousette, A., Persson, O., Kjellberg, A. A., Grundell, L. O., Soprani, J., Bogaardh, B., m.fl. (2003). An easy-to-use participative video-computer method for ergonomic evaluation of complex work. Proceeding of IEA (pp 592–95). Seoul.

Mathiassen, S. E., Liv, P., & Wahlström, J. (2012). Cost-efficient observation of working postures from video recordings–more videos, more observers or more views per observer? Work: A Journal of Prevention, Assessment and Rehabilitation, 41, 2302–2306.

Palm, P., Hogstedt, C., Balogh, I., Hansson, G.-Å., & Forsman, M. (2013). Efficient ergonomic evaluation by combining low-cost video editing software and measurements. Presented at the NES Conference Ergonomics for Equality, Reykjvavik.

Rezagholi, M., Mathiassen, S. E., & Liv, P. (2012). Cost efficiency comparison of four video-based techniques for assessing upper arm postures. Ergonomics, 55(3), 350–360.

Rosén, G., Andersson, I.-M., Walsh, P. T., Clark, R. D. R., Säämänen, A., Heinonen, K., Riipinen, H., m.fl. (2005). A review of video exposure monitoring as an occupational hygiene tool. The Annals of occupational hygiene, 49(3), 201–217.

Spielholz, P., Silverstein, B., Morgan, M., Checkoway, H., & Kaufman, J. (2001). Comparison of self-report, video observation and direct measurement methods for upper extremity musculoskeletal disorder physical risk factors. Ergonomics, 44(6), 588–613.