A Video System for Measuring School Children Sitting Posture Dynamics

Borut Kirn *borut.kirn@mf.uni-lj.si*
Medical Faculty
University of Ljubljana
Ljubljana, 1000, Slovenia

Vito Starc *vito.starc@mf.uni-lj.si*
Medical Faculty
University of Ljubljana
Ljubljana, 1000, Slovenia

Abstract

School children spent a lot of time sitting. Some Primary Schools in Slovenia were interested to improve pupil's working conditions by introducing more dynamic type of sitting. A standard school chair was substituted with a large gymnastic ball. In order to evaluate influence of this substitution on sitting dynamics we developed a video system capable of assessing sitting posture in sagittal plain during prolonged period.

We composed a video acquisition system with video camera (Blaupunkt, CCR 808), simple optical markers with LED diodes and robust image analysing software. To test it we measured the sitting posture of eight school children, who were sitting for 30 minutes on a large gymnastic ball and on a chair without a backrest and armrest with the acquisition rate 3 s^{-1}. Each image was analysed to determine position of markers and then the Lumbar Lordosis angle (LL) and the Pelvis Inclination angle (PI) time courses were calculated.

We found a measurement system very convenient in the conditions outside the laboratory. The level of backscatter which could impair automatic marker location extraction from the recorded image was low during all sessions. The marker in the recorded image had 30$\pm$10 pixels with different intensity. We found that during first 6 minutes the posture is more upright on the ball as compared to the chair (PI: chair $17.0^0 \pm 7.2^0$, ball $13.2^0 \pm 8.5^0$, $p<0.05$; LL: chair $-5.1^0 \pm 2.5^0$, ball -$4.8^0 \pm 2.1^0$, $p>0.05$).

A measurement system using consumer video camera, LED video markers and image analytics software is cost effective and reliable system which has minimal influence on students comfort during measurements outside the laboratory.

Keywords: Sitting, Dynamic, Posture, Measurement, Video, School.

1. INTRODUCTION

Young children spend a lot of time in school (Linton et al. 1994) and most of that time they are usually sitting (Storr-Paulsen and Aagaard-Hensen 1994). Parents, teachers and others involved are often concerned about the influence that prolonged sitting yields on the physical development of a child. To reduce side effects of prolonged sitting, more ergonomic classroom furniture is frequently suggested as one of the solutions (Knight and Noyes 1999, Marschall et al. 1995, Schröder 1997). Therefore, some schools in Slovenia have attempted to substitute a standard classroom chair with a large gymnastic ball. From a semi static sitting posture on a chair, a more dynamic sitting posture was expected on a ball. However, there is no evidence how such a substitution could influences the sitting posture. Whether to support this theory or to oppose it, makes the professional judgment to be very difficult. For this purpose, we chose to evaluate the difference between sitting posture obtained on a chair and on a ball during a prolonged period of sitting.

The idea to substitute a chair with a ball in the classroom is not new. In some schools in Switzerland, it has already been practiced for a period of one year. In parallel investigations (Knusel and Jelk 1994, Amstad et al. 1992), they re-examined the standing posture, the balance and strength of particular muscles in participants after one year, but they found little if any improvement. However, they did not study the change of the sitting posture itself. They reported that when incorporating movement into the classroom context, the ball might be helpful and that it was well-received as an alternative to the conventional sitting.

Nevertheless, it has been shown that periodic changes of the sitting posture influence the spinal load (Lengsfeld et al. 2000). Continuous measurements of lumbar spine kinematics have shown (Callaghan and McGill 2001) that this type of information is necessary for an ergonomist to evaluate the different styles of sitting.

In order to evaluate the influence of different types of chairs on school children posture we developed a video measurement system capable of assessing sitting posture in sagittal plain during prolonged period.

2. METHODS

2.1. Experimental Participants

Eight physically normal developed school children (10-11 years old; 4 male, 4 female) were participating in the experimental study. Their average height was 147.2±4.0 cm and their average weight was 38.0±5.1 kg. A week before the measurement, a trained physiotherapist explained them how to sit on the ball. After that, each child was sitting on the ball during classes for at least one day. The investigation was approved by the ethical commission and a parental approval was acquired for every child.

2.2. Experimental Protocol

Prior to the experiment, the height and popliteal height of each child were measured to enable appropriate adjustment of the size of the ball and of the chair. Pupils were sitting on a ball and on a chair during two separated sessions each lasting for 30 minutes.

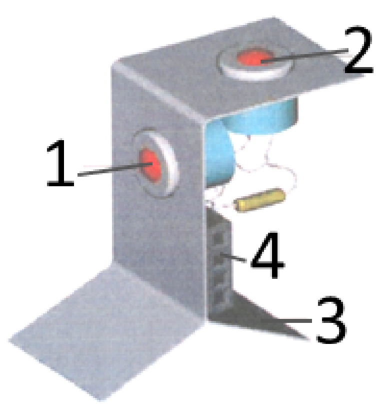

FIGURE 1: Optical skin marker construction: (1) sagittal plane LED, (2) frontal plane LED, (3) light metal holder and (4) electric connector.

2.3. Assessment of Sitting Posture

Each subject was recorded from a lateral view using Blaupunkt CCR 808 video camera operating at 25 frames per second. The camera, levelled on the tripod, was located 5 m from the subject at

1 m height and positioned perpendicular to the plane of motion to decrease errors of perspective. Five markers constructed of a LED diode fixed on the free end of a 2 cm long holder (Figure 1), were positioned at the most superior parts of the spinal prominence of lumbar vertebrae L1, L3 and L5, of sacrum S2 and at the Anterior Superior Iliac Spine (ASIS) (Figure 2).

The intensity of the light in the room was low: therefore, the optical markers were clearly visible on the recorded image. Images, which were digitised and fed into the computer with spatial resolution of 320x280 pixels and with an acquisition rate of 3 frames per second, were analysed to find the position of each marker. For this purpose, we developed motion analysis software, which found the position of the marker in the first image and traced its position during the rest of the session. Each marker on the image was a blob of 30±10 pixels which had much higher brightness than the background pixels. For each marker we used intensity of pixels to determine its center as an equivalent to a center of mass.

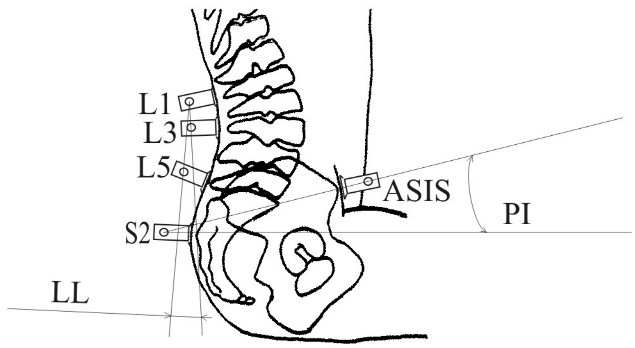

FIGURE 2: Optical skin markers, which were used in definitions of the two angles: the Pelvis Inclination (PI) and the Lumbar Lordosis (LL).

2.4. Definition of Angles
The marker's coordinates were used to determine two angles, which served to describe the sitting posture. As shown in figure 2, the Pelvis Inclination angle (PI) was defined as the sharp angle between the line connecting markers S2, SAIS, and the horizontal line. The Lumbar Lordosis angle (LL) was defined with markers L1, L3 and L5. One line connected L1 to L3 and the second one connected L1 to L5. The angle was considered negative in the case of kyphotic lumbar curvature. Altogether, 5400 consequent values of the PI and LL were determined for each session.

2.5. Data Analysis and Statistics
The average value of the first six minutes of each time course was considered as the initial sitting posture. A paired t-test was used to compare values obtained from sitting on a ball and sitting on a chair.

3. RESULTS
We recorded sitting posture of 8 pupils while sitting on a ball and on a chair (Figure 3). We were able to extract all markers with less than 0.01% of drop-off. The PI and LL angle values were meaningful and reflected the dynamics of sitting.

During the measurement the pupils were not affected much by the procedure of the measurement and could continue with their regular classroom work by the table.

When comparing initial postures (Figure 4), we observed that PI is smaller when a person is sitting on a ball (chair: $17.0^0 \pm 7.2^0$, ball: $13.2^0 \pm 8.5^0$, $p<0.05$), while no significant difference was found in LL (chair: $-5.1^0 \pm 2.5^0$, ball: $-4.8^0 \pm 2.1^0$, $p>0.05$).

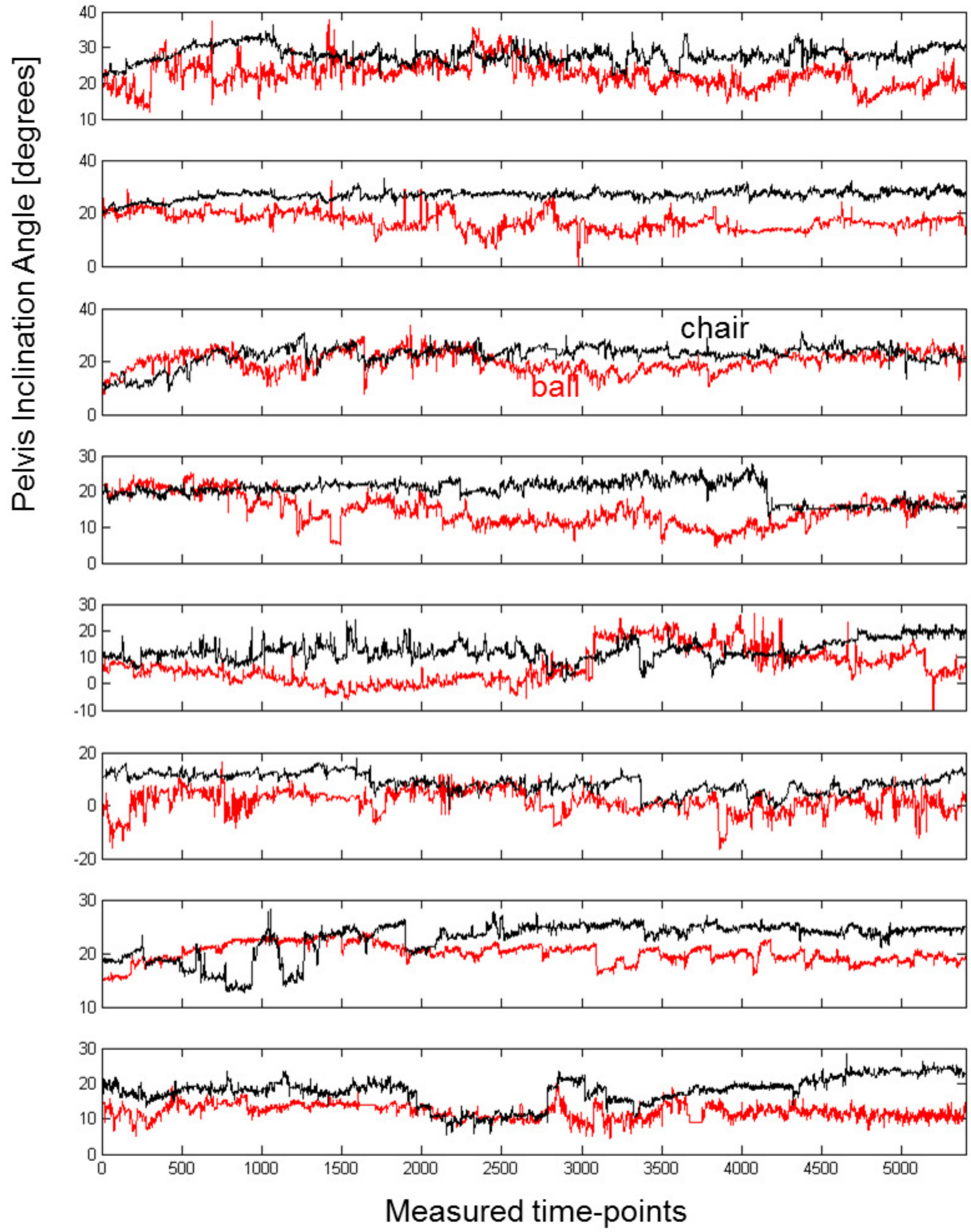

FIGURE 3: The time course of the Pelvis Inclination (PI) as measured in subjects 1 to 8 during sitting on the chair (black) and during sitting on the ball (red) for all 5400 measured time points (acquisition rate 3 s^{-1}).

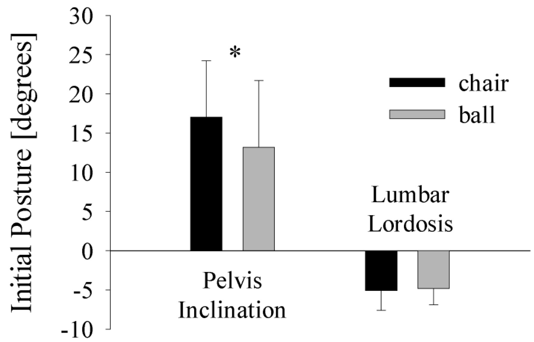

FIGURE 4: The initial postures (the average of the first six minutes) of all the participants, individually for each angle (Pelvis Inclination, Lumbar Lordosis). (*, p<0.05 chair vs. ball).

4. DISCUSSION

Sitting still is not always a good thing. The kids are very wiggly because their sensory system is still developing. There are many arguments for pro and contra introduction of the ball as a chair in the classroom. We believe that with our video system could add scientific arguments to this discussion.

We were able to record the video, extract the markers, calculate the angles and present them. The angle values were meaningful and reflected the dynamics of sitting. We achieved that despite axial rotation of pupils which could direct the LED light beam away from the camera or even shield the marker from visual contact. The length of the marker rod and the application of LED appeared right selection.

The dynamics and biomechanics of sitting is complex (Schult et al. 2013). It will take some time to properly analyze by using statistics, human posture load models, frequency analyses and others. Using a ball in the classroom instead of a chair changes many aspects of the classroom atmosphere (Knusel and Jelk 1994, Amstad et al. 1992). The dynamic sitting is effective as a sitting furniture for students who exhibit sitting discomfort and problem-based learning (Al-Eisa et al. 2013).

We observed that the initial posture was more upright on the ball, which was indicated by small PI. In the continuation of sitting, the PI showed no trend of rise; rather contrary, it became even slightly lower. Therefore, the posture on the ball maintained or even improved the initial uprightness (negative PI slope). That is the very opposite to the sitting on the chair, where initial posture is more relaxed (bigger PI) and in continuation of sitting session, the posture became even more slouch (positive PI slope). However, considering the initial postures and the slopes, no significant difference was measured in LL. That is partially due to the movements of the upper part of the body, which influence LL values.

From the measurements we could see that there is more movement on the ball. It is known that rotatory dynamic sitting changes spinal load and increases its length (van Dieen et al. 2001, Groenesteijn et al. 2012). Therefore, it is to expect that the dynamic sitting is beneficial: however, the maximum effect would probably be achieved when the periodicity of movements, when sitting, is similar to the periodicity of movements during walking or balancing during standing, because the body is adapted to it (Kirn and Starc, 2014).

Our acquisition system generates large amount of data. In the future this data should be analysed to reveal systemic influence of sitting strategy on soft tissue loads. In addition we recommend increasing acquisition rate to $25s^{-1}$ in order to enable studying of high frequency movements.

A potential drawback of our study is that the video acquisition which we developed assesses the posture in one plain that is in two dimensions. There are other techniques which enable three dimensional assessment of sitting posture (Brink et al. 2013) but they are considerably more expensive. In addition the 3D system generates even more data per unit of time and is therefore to strong because adequate analytical tools for posture dynamics analyses are not yet developed.

5. CONCLUSION

A measurement system using consumer video camera, LED markers and image analytics software is cost effective and reliable system which has minimal influence on students comfort during measurements outside the laboratory. It enables differentiation between different types of sitting furniture.

Sitting on the ball yields more upright initial sitting posture which is beneficial for children. Therefore the study supports schools to occasionally substitute schools stool with large gymnastic ball.

6. ACKNOWLEDGMENT

We thanks to Alenka Pučko, dipl.physiotherapist for her skill full acquisition of the data and to teachers and pupils of Primary school Kolezija – Ljubljana for their participation in the study.

7. REFERENCES

[1] Al-Eisa E, Buragadda S, Melam GR. Effect of therapy ball seating on learning and sitting discomforts among Saudi female students. Biomed Res Int. 2013;2013:153165.

[2] Amstad, H., Bachlin, A. and von Arx, N. 1992, Sitzball oder Stuhl im Klassenzimmer?, Schweiz Med Wochenschr 122, 811-6.

[3] Brink Y, Louw Q, Grimmer K, Schreve K, van der Westhuizen G, Jordaan E. Development of a cost effective three-dimensional posture analysis tool: validity and reliability. BMC Musculoskelet Disord. 2013 Dec 1;14:335.

[4] Bryant, J.T., Reid, J.G. and Smith, B.L. 1989, Method for determining vertebral body positions in the sagittal plane using skin markers, Spine 14, 258-65.

[5] Callaghan, J.P. and McGill, S.M. 2001, Low back joint loading and kinematics during standing and unsupported sitting, Ergonomics 44, 280-94.

[6] Groenesteijn L, Ellegast RP, Keller K, Krause F, Berger H, de Looze MP. Office task effects on comfort and body dynamics in five dynamic office chairs. Appl Ergon. 2012 Mar;43(2):320-8.

[7] Holm, S. and Nachemson, A. 1983, Variations in the nutrition of the canine intervertebral disc induced by motion, Spine 8, 866-74.

[8] Kirn B. and Starc V. "Frequency Analyses of Postural Sway during Prolonged Sitting on a Large Gymnastics Ball and Stool." American Journal of Sports Science and Medicine 2014. 2.1: 17-20.

[9] Knight, G. and Noyes, J. 1999, Children's behaviour and the design of school furniture, Ergonomics 42, 747-60.

[10] Knusel, O. and Jelk, W. 1994, Sitzball und ergonomisches Mobiliar im Schulzimmer, Schweiz Rundsch Med Prax 83, 407-13.

[11] Lengsfeld, M., van Deursen, D.L., Rohlmann, A., van Deursen, L.L. and Griss, P. 2000, Spinal load changes during rotatory dynamic sitting, Clinical Biomechanics 15, 295-7.

[12] Linton, S.J., Hellsing, A., Halme, T. and Akerstedt, K. 1994, The effects of ergonomically designed school furniture on pupils' attitudes, symptoms and behaviour, Applied Ergonomics, 25, 299-304.

[13] Marschall, M., Harrington, A.C. and Steele, J.R. 1995, Effect of work station design on sitting posture in young children, Ergonomics 38, 1932-40.

[14] McGill SM, Hughson RL, Parks K. 2000, Lumbar erector spinae oxygenation during prolonged contractions: implications for prolonged work, Ergonomics 43, 486-93.

[15] Pucko A. 1999, Drza osnovnosolca pri sedenju na obicajnem stolu in veliki gimnasticni zogi. Diplomsko delo, Univerza v Ljubljani

[16] Roozmon, P., Gracovetsky, S.A., Gouw, G.J. and Newman, N. 1993, Examining motion in the cervical spine I: imaging systems and measurement techniques, Journal of Biomedical Engineering 15, 5-12.

[17] Schroder, I. 1997, Variations of sitting posture and physical activity in different types of school furniture, Coll Antropol 21, 397-403.

[18] Schult TM, Awosika ER, Schmunk SK, Hodgson MJ, Heymach BL, Parker CD. Sitting on stability balls: biomechanics evaluation in a workplace setting. J Occup Environ Hyg. 2013;10(2):55-63.

[19] Storr-Paulsen, A. and Aagaard-Hensen, J. 1994, The working positions of schoolchildren, Applied Ergonomics, 25, 63-64.

[20] Van Dieen, J.H., de Looze, M.P. and Hermans, V. 2001, Effects of dynamic office chairs on trunk kinematics, trunk extensor EMG and spinal shrinkage, Ergonomics 44, 739-50.