

Pilot Study of Wobble Seat on Trunk Muscles Activity and Kinematics

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1. Introduction

Insufficient lumbar stability is known as a potential mechanism which is associated with disability and lower back pain [1]. The motor control challenge for the individuals is to use their lumbar spine to minimize the seat displacement, when sitting on unstable surface, with smaller movements representing better performance [1]. This requires a good connection between feedforward and feedback motor control mechanisms. Feedforward control can change lumbar stiffness because of trunk muscle co-contraction. However, too much trunk muscle co-contraction can reduce trunk postural control during unstable sitting. Other studies also show, that individuals with non – specific lower back pain have shown poorer postural control during sitting [2]. During standing and sitting, impaired proprioception has been suggested as a possible mechanism causing the impaired postural control [2].

When postural conditions change, the central nervous system (CNS) must identify and select the sensory inputs to provide good control. The CNS weight inputs from the vestibular, the visual and the proprioceptive system. So, to maintain a good equilibrium the task is to control efficiently the center of mass by muscle forces [2]. Thus, the postural control in lower back pain can be affected by factors such as reduction in somatosensory input when visual and vestibular inputs are intact. Also, postural control can be affected by other factors such as: age, external loads, localized muscle fatigue, neurological deficits, and musculo-skeletal disorders (back pain) which reduce the quality of afferents [3]. There are a lot of studies which analyzing trunk control between different population [4], the effect of applied trunk forces [5], whole body vibration [6] or vibrotactile feedback devices [7], [8], or sensory manipulation on trunk control [9]. To increase trunk stability and deep muscles activity all these devices and strategies mentioned before are applied.

The most studies show unstable base of support, when center of mass changes during unstable sitting [10], [5], [11], [12] or standing [13]. There are several types of base have been use in unstable sitting: a central ball bearing [14], [15], a central ball and springs [5], [16], [12], [17], [10], and hemispherical bases [4], [18], [19]. The perturbation of postural control acts when trunk moves to different directions. The important features of unstable base of support, such as chairs with movable seat, are that it increases

the range of the pelvis movement or forces the pelvis movement [20]. The more engaging the pelvis motion, the more engaging of the muscles supporting the spine [20].

2. Testing procedures

Our study is a pilot study, one subject (man) participated in our experiment. Age 40 years old, weight 80 kg, height – 180 cm.

The trunk muscles activity was measured during the balance testing by surface electromyograph (sEMG) (Noraxon MR3.6). Bipolar EMG activity was recorded using surface electrodes from the right side of: m. transversus, m. obliquus externus, m. rectus abdominis, m. erector spine (thoraco – lumbar part), m. multifidus. Before the surface electrodes placement on the skin was shaved, swabbed and rubbed with alcohol to reduce skin impedance. sEMG data were band-pass filtered (the frequency range 5–500 Hz) then rectified and smoothed. The amplitude of sEMG data was normalized using the mean dynamic activity method. For further calculations and results comparison between patients, maximum voluntary isometric contraction (MVIC) was performed for each muscle and the sEMG amplitude recorded at the same time.

Three-dimensional kinematic data were recorded by motion capture with 10 Oqus3+ (Qualisys AB, Gothenburg, Sweden) cameras Fig.1 and the Qualisys Track Manager software at a sampling frequency of 300 Hz. The Helen-Hayes marker set was used for measuring full – body kinematics.

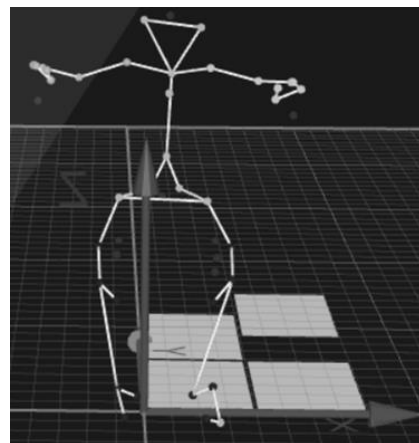


Fig. 1 Sitting human model with active markers

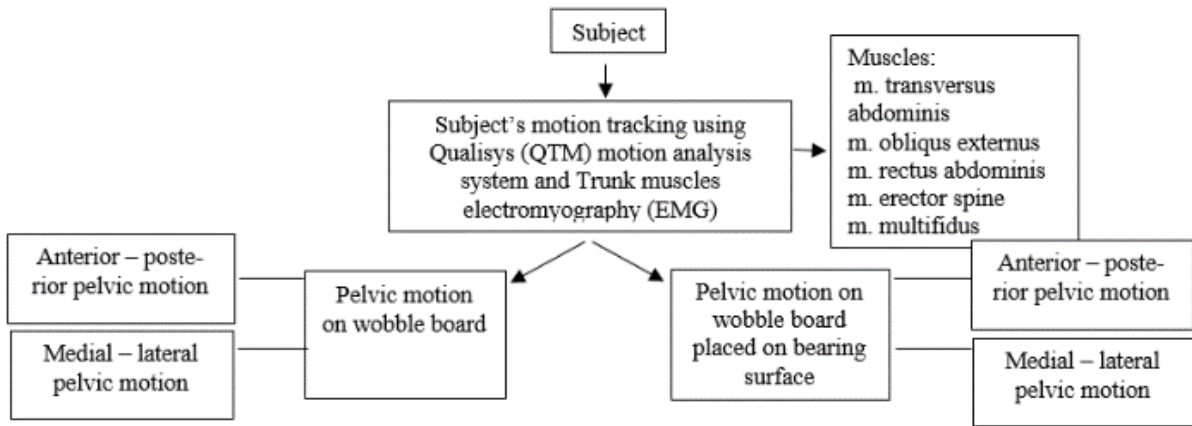


Fig. 2 Testing protocol

Experiment was done on testing protocol Fig. 2. Experimental task was done on two different sitting surface Fig. 3 with two pelvic motions on them. The first task was sit on wobble board Fig. 3 and do two pelvic motions: anterior – posterior pelvic motion and side to side pelvic motion. The second task was sit on wobble board which was placed on bearing surface Fig. 3, the pelvic motions were: anterior – posterior pelvic motion and side to side pelvic motion.

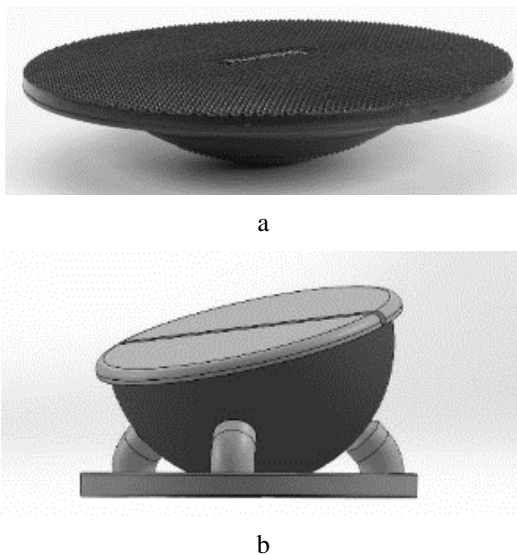


Fig. 3 a) a simple wobble board and b) wobble board placed on bearing surface

3. Results

3.1. Trunk muscles activity on two different surfaces

Person multifidus muscle activity acting anterior – posterior pelvic motion on wobble board was 17,38%, while sitting on wobble board on bearing surface was 23,07%. Also, the multifidus muscle activity was higher (23,07%) than erector spine muscles activity (16,64%) on wobble board on bearing surface. Externus obliquus muscles activity (20,83%) when sat on wobble board on bearing surface was higher than transversus (13,77%) and rectus abdominis (8,16%) muscles. Meanwhile, sitting on wobble board the abdominis muscles activity were lower than sitting on wobble board on bearing surface Fig. 4.

During side to side pelvic motion, the multifidus muscles activity, were lower on wobble board on bearing

surface 15,19% than on wobble board 21,28%. Also, transversus muscle (24,83%) and externus obliquus muscle (29,82%) activity was higher on wobble board on bearing surface than on wobble board (transversus muscle (18,41%) and externus obliquus muscle (19,68%) Fig. 5.

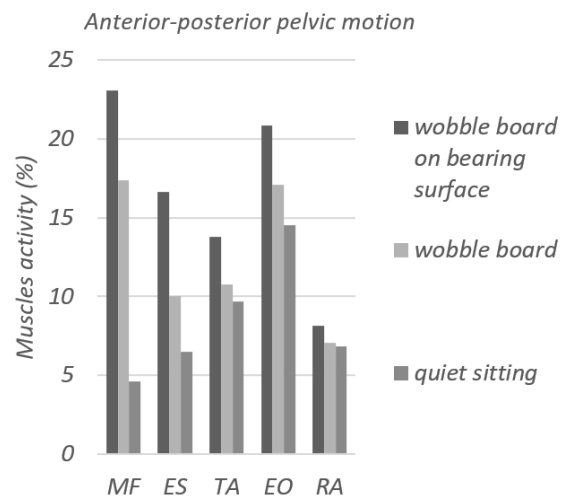


Fig. 4 Trunk muscles activity in anterior – posterior pelvic motion (MF – m. multifidus; ES – m. erector spine; TA - m. transversus abdominis; EO – m. obliquus externus; RA – m. rectus abdominis)

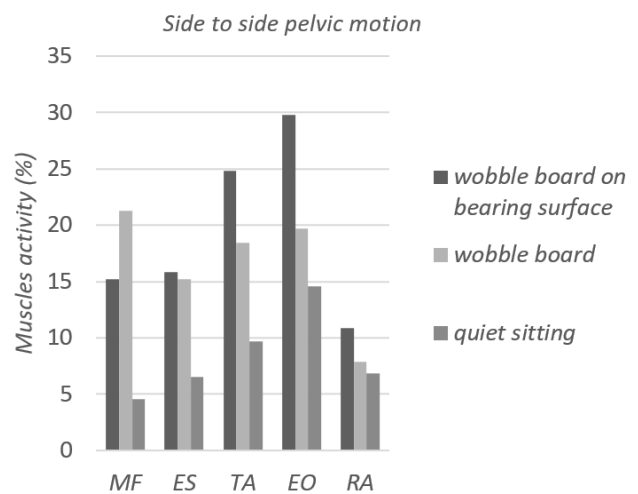


Fig. 5 Trunk muscles activity in side to side pelvic motion (MF – m. multifidus; ES – m. erector spine; TA - m. transversus abdominis; EO – m. obliquus externus; RA – m. rectus abdominis)

3.2. Kinematic body segments analysis

During anterior – posterior pelvic motion on wobble board on bearing surface, the degrees of pelvis related to sitting surface was lower $64,44^\circ$, than on wobble board – $70,81^\circ$ Fig.6. However, side to side pelvic motion on wobble board on bearing surface was higher $80,06^\circ$, than on wobble board – $86,20^\circ$ Fig. 7

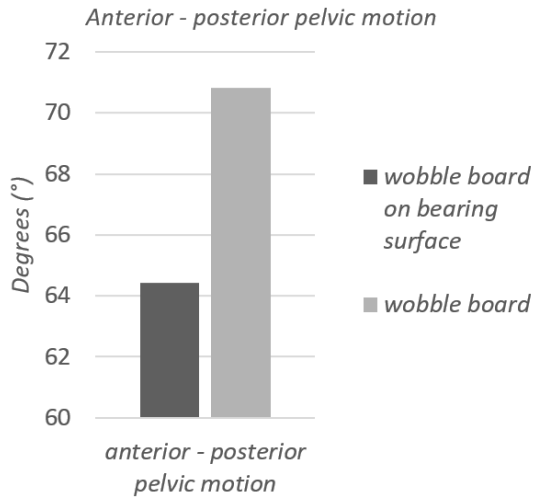


Fig. 6 Pelvis angle in anterior – posterior pelvic motion

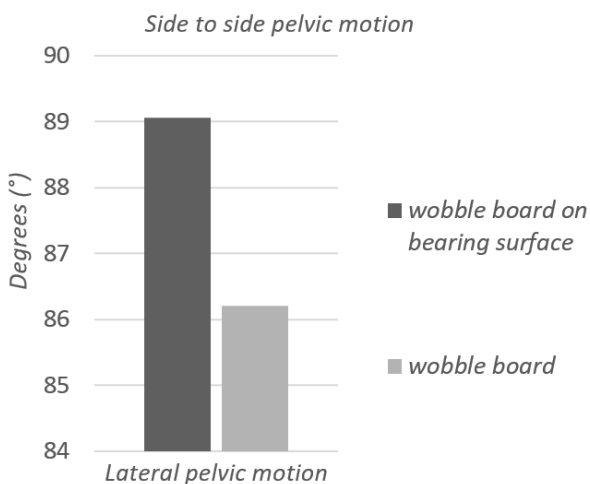


Fig. 7 Pelvis angle in side to side pelvic motion

4. Discussion

The purpose of this experiment was to compare person's trunk muscles activity and kinematic body segments movement when sitting on different platforms: simple wobble board and wobble board placed on bearing surface. The wobble board placed on bearing surface was selected due to find are the deep muscles more active than superficial muscles and how the angle of pelvis changes during movement on different surfaces. The main findings were that doing anterior – posterior pelvic motion on wobble board on bearing surface, all muscles had higher activity than doing the same motion on simple wobble board, but the anterior – posterior pelvis motion angle was lower on wobble board on bearing surface, than on wobble board. The goal of the wobble board and person dynamic system is to stabilize the upper body. Mechanically, the wobble board is lighter, and of lower inertia compared to the upper body [16]. For this reason, we assume, that our body system is

most effectively stabilized by regulating the motion of the wobble board placed on bearing surface due to higher activity of deep trunk muscles and lower angle of pelvic motion. This wobble board on bearing surface can be potential to train seated balance and pelvic motion in clinical populations [17], when neuromuscular control of pelvis and lumbar spine are affected and people with lower back pain cannot move pelvis isolated [18].

Talking about side to side pelvic motion muscles transversus abdominis and externus obliquus abdominis had higher activity on wobble board on bearing surface, than on simple wobble board. However, the higher angle, doing side to side pelvic motion, was on simple wobble board, than on wobble board on bearing surface.

This experiment used a hemispherical base which was placed on bearing surface of the sitting surface to induce unstable sitting and pelvic motion. Our findings of wobble board placed on bearing surface can be other type of unstable sitting idea.

5. Conclusions

1. Sitting on wobble board placed on bearing surface led to increment of the activity of deep muscles, which are responsible for spine stabilization, especially in anterior – posterior pelvic motion.
2. This bearing surface let to do smaller pelvis motion and gave higher muscles activity than on simple wobble board.
3. Wobble board placed on bearing surface could be adjusted to decrease superficial muscles activity and increase deep muscles activity, especially those people who have impaired neuromuscular control in lumbo – pelvic region. Nevertheless, there is still a need of further research, considering larger sample sizes and improvement of wobble board placed on bearing surface.

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PILOT STUDY OF WOBBLE SEAT ON TRUNK MUSCLES ACTIVITY AND KINEMATICS

S u m m a r y

This paper presents the pilot study of wobble seat on trunk muscles activity and kinematics. For this study the wobble board and wobble board on bearing surface were used to compare muscles activity and body segments kinematics on these different platforms. Two pelvic motions were performed: anterior – posterior and side to side. Results showed that sitting on wobble board placed on bearing surface led to increment of the activity of deep muscles with smaller pelvic movement in anterior – posterior pelvic motion.

Keywords: wobble board, wobble seat, sitting, bearings, muscles activity, kinematic analysis.

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