International Journal of Obstetric Anesthesia (2014) **23**, 227–232
0959-289X/$ - see front matter
http://dx.doi.org/10.1016/j.ijoa.2014.02.001

ORIGINAL ARTICLE

ELSEVIER
www.obstetanesthesia.com

Utility of a low-cost wireless force platform as a potential clinical test of balance recovery after neuraxial anaesthesia

N. Tweed, S. Williams, D. Williams, J. Dingley
Department of Anaesthetics and Intensive Care, ABM University Health Board, Swansea, UK

ABSTRACT
Introduction: Recovery of balance after neuraxial anaesthesia can remain delayed after simple clinical tests have demonstrated motor recovery. Dynamic posturography tracks the small movements or sway of a person standing as still as possible on a force platform and has been investigated as an objective measure of the ability to walk following anaesthesia. These are expensive laboratory devices, limiting their clinical utility. One measured variable is path length, the cumulative distance travelled in the horizontal plane by the centre of pressure of a person standing on the platform over 1 min. Path length might potentially be measured using the Nintendo® Wii-Fit Balance Board™.
Methods: The feasibility of intercepting raw wireless data from a Wii-Fit Balance Board™ using custom software to calculate path length was explored. Subsequently, path lengths were measured using both this and a laboratory platform simultaneously. In a random order 20 volunteers (a) stood for 1 min, feet together, eyes open (conventional baseline test); and (b) stood for 1 min, feet together, eyes closed (simulating residual anaesthesia with increased sway). For each device, the ratio b:a was calculated as an index of performance reduction when eyes were closed.
Results: Path lengths ranged from 58.5 to 243 cm, mean bias 9 cm (Wii-Fit < laboratory platform) and 95% confidence limits of 2.5–15.4 cm. Ratios ranged from 1.09 to 2.68, mean bias −0.04 (Wii-Fit > laboratory platform) and 95% confidence limits of 0.04 to −0.13.
Conclusions: The path lengths were in close agreement and the Wii-Fit Balance Board™ may be worthy of further investigation as a tool to objectively assess readiness to ambulate following neuraxial anaesthesia.

Keywords: Anaesthesia; Neuraxial; Posturography; Path length; Wii-Fit Balance Board™

Introduction

There are a number of clinical tests of readiness to walk unaided, particularly after neuraxial anaesthesia, including the straight-leg lift, deep-knee bend and heel-to-shin touch. Evaluation of these tests is subjective and the underlying assumption that motor function recovery indicates readiness to mobilise, is not necessarily true.[1–3] These markers of gross motor function have been shown to be poor predictors of functional balance.[4] Sophisticated expensive laboratory systems exist for the evaluation of human balance which consist of a flat, rigid force platform instrumented with force sensors. If a subject is asked to stand on the platform as still as possible with their feet together, any slight movement of their centre of pressure or sway can be calculated from the proportional change in downward force on each corner of the platform. One commonly used parameter is the path length which represents the length of an imaginary line drawn by the slight movements of the centre of pressure in the horizontal plane over a period of time, typically 1 min, as the subject attempts to stand as still as possible. Such platforms have been used in many forms of physiological and medical research, including the study of residual effects of anaesthesia, effects of sedative drugs, alcohol and central neuraxial blockade.[3,5–12] It has been proposed that such platforms might be useful clinically to evaluate the capacity of patients to mobilise safely following neuraxial anaesthesia,. However, due to their high cost and cumbersome nature, this has not translated into the clinical setting.

There has been debate about the safety of allowing women to walk following low-dose neuraxial labour analgesia and it has been proposed that balance platforms may be used as an evaluation tool in such women. In a study of recovery of proprioception and vibration sense following low-dose bupivacaine/fentanyl neuraxial analgesia for labour, 10% of women had abnormal lower limb motor power and/or dorsal column function due to the residual effects of analgesia when attempting to ambulate. Assessment of these parameters was therefore

Accepted February 2014
Correspondence to: Dr. John Dingley FRCA MD, Department of Anaesthetics and Intensive Care, Morriston Hospital, Swansea, West Glamorgan SA6 6NL, UK.
E-mail address: j.dingley@swan.ac.uk

recommended before allowing patients to walk after low-dose neuraxial techniques.[13] In a later study where a force platform had been used to evaluate patients after a low-dose combined spinal-epidural (CSE) technique, patients demonstrated generally preserved balance function. Although a small, significant reduction in one of six posturographic sensory-organisation tests was observed, the difference was functionally minor.[14] More recently, balance during a series of simple tasks, including walking and standing up from sitting, was evaluated after CSE labour analgesia. There was little impairment of function after the initial low-dose spinal; however, those who later received epidural supplementation exhibited an impairment of balance. This study supported the practice of allowing women to ambulate following initial low-dose spinal analgesia.[15]

It is known that a Nintendo® Wii-Fit Balance Board™, although low in overall cost, nevertheless contains high quality force sensors and transmits data wirelessly via a completely standard Bluetooth protocol as used in many electronic devices. It might therefore be possible, after suitable signal processing, to derive centre of pressure measurements and therefore path length values of sufficient quality from this raw wireless data stream to render this a clinically useful, wireless, portable tool. With further research this might enable development of low cost objective bedside testing.

Since the Wii-Fit Balance Board™ became available, researchers have evaluated its utility as a physical therapy tool over a period of repeated sessions, particularly in the elderly to improve balance.[16,17] However, when examined as a balance assessment tool, balance test scores derived from games software supplied by the manufacturer correlated only moderately well with a number of known equivalent medical scoring systems.[18] Such correlations improved when raw data from the Wii-Fit Balance Board™ were used to derive balance variables such as the path length when compared in random order with a repeat measurement made using a laboratory force platform.[19]

We evaluated whether it was technically feasible to intercept unprocessed raw wireless data from Wii-Fit force sensors using a Bluetooth-enabled laptop computer, develop appropriate signal conditioning, calculate the movement of centre of pressure and then from this derive the path length value. In healthy volunteers, it was then investigated whether the Wii-Fit platform/computer combination generated path length balance values in sufficient agreement with those measured simultaneously using a physiology laboratory balance measurement system to justify further investigation of the Wii-Fit Balance Board™ as a potential clinical tool.

Methods

Having initially tested the technical feasibility of the equipment (Appendix A) we proceeded to compare path lengths derived simultaneously using the Wii-Fit Balance Board™ (Nintendo, Kyoto, Japan) and a physiology laboratory balance measurement platform (Accusway, AMTI Force and Motion, Watertown, MA, USA). Twenty volunteers from within the department of anaesthesia and intensive care within our institution were recruited. The opinion of the regional ethics committee was sought and formal ethical approval for this study was not required.

The Accusway force plate balance measurement system is a commercial laboratory tool costing approximately US $12 000. It comprises a 4 cm thick non-moving metal plate equipped with sensors. This was connected via a cable to a personal computer running software supplied by the manufacturer. The Wii-Fit Balance Board™ is battery-operated, transmitted data using a built-in short range Bluetooth wireless system and costs approximately US $120. These data were received by a standard Bluetooth receiver module plugged into the USB port of a laptop computer which collected and stored data. Neither force platform system was physically modified in any way. It was hypothesised that the processed centre of pressure sway data or path length, would be similar from both systems.

Both platforms were completely rigid during use with no moving parts and both had a narrow thickness. Therefore, in order to compare simultaneous data from each plate, one was placed on top of the other on a solid floor, with the subject standing on the uppermost plate. The centres of each plate were exactly placed above each other by careful measurement and positioning.

The centre of pressure of a subject standing on a force plate was derived from the ratios of the vertically downward acting forces measured at each corner. The objective was not to weigh the patient. Therefore, the centre of pressure was not affected by the absolute weight of the subject, and remained accurate so long as they stood within the corner boundaries of each force plate. The path length was not affected by where the subject stood relative to the centre of the force plate. This is because path length is a measure of the cumulative distance of travel of the centre of pressure over a period of time; so it did not matter whether the path started from the centre of the plate or not. Neither of the force plates moved during use, and each could be considered in physical terms as solid flat surfaces.

Male and female volunteers >18 years of age were considered eligible for the study. A maximum weight of 150 kg was specified as the Wii-Fit Balance Board™ had a weight limit of this value, while that for the Accusway was greater. Exclusion criteria were an inability to stand unaided, inability to understand the procedure, vision impairment persisting after correction, and known impairment of balance due to a neurological or vestibular problem.

Before completing the study, each subject received an information sheet outlining the study procedure and