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RESEARCH PAPER

Reliability and validity of a force-instrumented treadmill for evaluating balance: A preliminary study of feasibility in healthy young adults☆

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KEYWORDS
balance evaluation;
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Abstract *Background:* With the development of computer technology, computerized dynamic posturography provides objective assessments of balance and posture control under static and dynamic conditions. Although a force-instrumented treadmill-based balance assessment is feasible for balance evaluations, currently no data exists.
Objective: This study was undertaken to assess the reliability and validity of balance evaluations using a force-instrumented treadmill.
Methods: Ten healthy adults participated in evaluations using both the treadmill and the EquiTest. Four balance evaluations were conducted: Modified Clinical Test of Sensory Interaction on Balance, Unilateral Stance, Weight Bearing Squat, and Motor Control Test.
Results: All balance evaluations using the force-instrumented treadmill method shared good reliability (intraclass correlation coefficient $\geq$0.6). The Modified Clinical Test of Sensory Interaction on Balance, Unilateral Stance, and Weight Bearing Squat evaluations had a correlation

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of $r < 0.5$ with EquiTest, whereas the Motor Control Test balance evaluation had moderate correlations ($r > 0.5$) with the EquiTest.
Conclusion: The results demonstrated that all balance evaluations using the force-instrumented treadmill were reliable, and that the Motor Control Test evaluation was moderately correlated with the EquiTest. Therefore, the use of a force-instrumented treadmill in balance evaluations might provide a certain level of value to clinical practice.

Introduction

With the marked increase in the aging population, falls in the elderly are becoming a serious problem for our society. Fall-related injuries, for example, femoral neck fractures or vertebral compression fractures, limit the activities of daily living and influence mortality rates in the elderly [1,2]. It has been reported that balance impairment is one of the major causes of falling in the elderly [3,4]. For example, increases in the range of postural sway in the medial—lateral direction are associated with increased fall risks [5]. A review focused on fall screening assessment reported a correlation between the scores on balance assessment scales, such as the Berg Balance Scale and the Step Test, and the risk of falling [6]. Thus, it is quite important to develop useful balance assessment tools and improve the evaluations of balance so as to prevent serious fall-related injuries.

A variety of assessment tools focusing on balance evaluation have been developed and validated [7,8]. Recently, with the development of computer technology, a new kind of evaluation has been used in clinical practice—computerized dynamic posturography [9—11]. Computerized dynamic posturography is a highly specialized, noninvasive assessment technique used to measure the adaptive mechanisms of the central nervous system, and to objectively quantify and differentiate among the wide variety of possible sensory, motor, and central adaptive impairments to balance control. Good examples of this technique can be found in the stabilograph [12], accelerometer [13], three-dimensional motion analysis system [14], and EquiTest [15—19].

The EquiTest provides objective assessments of balance and posture control under static and dynamic conditions [15—19]. The assessments are focused on functional balance evaluations, which are used to assess the entire range of balance and fall risks. The system is composed of computers, a suspension system for safety, a tiltable board covering the field of view, and a force platform for kinesiological analysis. The EquiTest has been developed for years, and has been used mainly for cases of dizziness in the head and neck or otolaryngology surgery [20] and for balance feature comparisons of fall and nonfall group balance cases [21]. The EquiTest has demonstrated good reliability and validity in previous studies [22,23].

A force-instrumented treadmill has recently been used in gait training [24—28]. Controlled movements of the treadmill's belt, and a handrail and/or suspension are beneficial for easy and safe gait training. In addition, the force-instrumented treadmill can easily obtain feedback information of ground reaction force during clinical gait evaluation and training. Furthermore, because the whole system can be set under the floor of rehabilitation exercise rooms, it has a high degree of usability for gait disorders. Although a treadmill-based balance assessment created by modifying the method of the EquiTest is feasible, no data exists to demonstrate that the force-instrumented treadmill can make such balance evaluations. As a preliminary evaluation of feasibility, the present study aimed to assess the reliability and validity of the force-instrumented treadmill compared with the EquiTest for standard standing balance evaluations in healthy young adults.

Materials and methods

Participants and experimental protocols

Ten healthy volunteers participated in this study. Prior to the present study, the required sample size was estimated according to a power analysis for the intraclass correlation coefficient (ICC). Based on previous studies [29,30], assumed ICC, assumed power level, and Type I error were set to 0.7, 0.7, and 0.05, respectively. Power analysis indicated that 10 participants would be needed to demonstrate the underlying reliability and validity of the force-instrumented treadmill for evaluating balance. All participants gave informed written consent, and the protocol was approved by the University Clinical Research Committee. Each participant was evaluated for balance function on both the force-instrumented treadmill (FTM-1200WA; Tec Gihan, Kyoto, Japan) (Figure 1) and the EquiTest (MPS-3102; NeuroCom, Clackamas, USA) (Figure 2). The participants were randomly divided into two groups; one was evaluated first with the force-instrumented treadmill and then 3 days later with the EquiTest, and the other was first evaluated with the EquiTest and then with the treadmill. Standard EquiTest assessments were used for both the force-instrumented treadmill evaluations and the EquiTest. The assessments consisted of four balance evaluations: the Modified Clinical Test of Sensory Interaction on Balance (mCTSIB), the Unilateral Stance (US), the Weight Bearing Squat (WBS), and the Motor Control Test (MCT).

Experimental setup

In the force-instrumented treadmill assessments, the apparatus consisted of a treadmill, a firm surface (Balance Master; NeuroCom) in different environmental conditions, a board covering for vision feedback, and a suspension clamp