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A REVIEW OF THE LITERATURE ON SENSOR-BASED DYNAMIC BALANCE TOOLS FOR POSTURAL STABILITY CONTROL

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Abstract
Equilibrium is the capacity to hold a position within the bounds of support or stability. It is demonstrated that the posture control system is crucial for preserving balance on a small support base. The intricate process makes it challenging to evaluate balancing capacities succinctly and completely. By examining numerous studies that evaluate postural balance using a variety of mechanical tools and offering a thorough summary of popular mechanical tools for this purpose, this study expands on earlier research. Finding the appropriate activity and equipment to regulate postural stability is the aim of this review. We used VOSviewer, a tool for analyzing bibliometrics from the Scopus database from Elsevier and Google Scholar, to conduct an electronic search across several prestigious journals. 154 relevant items were found after a literature search. A more thorough analysis reveals that the chosen literature solely discusses mechanical instruments for assessing static and dynamic balance. Only 12 articles from the evaluation satisfied the requirements. Four publications inertial balance sensors, Biodex Balance Systems, force plates, and 3D Joint Kinematic sensors are directly related to sensor-based dynamic tools for postural stability control, according to the search results. This sensor-based dynamic balance tool is a useful tool for teaching and assessing postural stability in a variety of contexts, including medical rehabilitation.
Keywords: Dynamic Balance, Sensors, Postural

INTRODUCTION

Equilibrium is the capacity to hold a position outside of the bounds of stability or support. Posture control is the ability to maintain, achieve, or restore balance during any activity or posture (Thompson LA dkk, 2024). Increased body sway, poor visual-proprioceptive coordination, a lower threshold of stability and functional ability, altered gait, and falls are all common signs of postural instability and imbalance in patients with vestibular disorders. Falls are the primary result of

postural abnormalities and are linked to a variety of neuromuscular diseases (Kharbat AF dkk, 2023). Because the legs offer a tiny amount of support, it is demonstrated that the posture control system is crucial for preserving equilibrium.

Establishing therapy goals, choosing treatment modalities, and providing progression and prognosis all require balance evaluation for patients with a range of clinical disorders (Ilg W dkk, 2023). The evaluation of balance capacity is a crucial part of the orthopedic and physiotherapy examination (Lyon MF dkk, 2023). Since the majority of functional tests do not involve instrumental measurement data in the assessment process, they are by their very nature subjective (Mahoney J, dkk, 2023). However, because functional testing don't require a lot of equipment, they are practical. The intricate process makes it challenging to evaluate balancing capacities succinctly and completely. Mobility (stability during drive), pseudomobility (dynamic and transfer body stability), and static body stability (stability to maintain the body in a static position).

It is crucial to keep in mind that this field of study is still in its early stages, despite the mounting data supporting the use of mechanical tools to assess posture, balance, and dynamics (Buckley C, dkk, 2019). As previously stated, a number of other systematic reviews have been released in the last few years. The purpose of this review was to assess how different balance problems affected the sample population's experience of postural abnormalities. By examining a large number of studies that employ a range of mechanical tools to evaluate postural balance and provide a thorough summary of popular mechanical tools for this purpose, the study builds on earlier work. This study's goal is to gather information on posture and balance control exercise equipment.

METHODOLOGY

Using VOSviewer as a bibliometrics analysis tool, databases are searched electronically through a variety of prestigious journals as part of the literature review implementation process. Only online electronic databases from Google Scholar and Elsevier's Scopus database were used to review the papers. Analyzing and identifying the keywords we acquire is made possible by the information we gather from pertinent sources. A thorough text analysis of about 154 papers published between 2015 and 2024 was part of the study. A concise report that provides suggestions or a synopsis of the research based on bibliometric analysis is the final product of this investigation.

RESULTS

Main information

A search of the literature turned up 154 papers about postural equilibrium. Twelve papers

satisfied the inclusion requirements for this evaluation after duplicates, posters, congressional abstracts, and other research that did not discuss mechanical techniques for measuring static and dynamic balance were eliminated. Four tools—the Inertial balance sensor, the Biodex balance system, the Forceplate, and the Inertial Sensor Based 3D Joint Kinematics—were chosen to be evaluated and used as balance training tools. These products are closely related to sensor-based balance tools.

The most popular scientific source

By measuring a system's inertial force, inertial balance sensors are commonly used to assess a system's stability or balance (Neville C, dkk, 2015). It may evaluate balance by examining acceleration, tilt, or vibration and detects the force generated by the movement. Magnetometers, gyroscopes, and accelerometers are examples of inertial sensing devices that are often employed.

Sensors analyze the force applied to an object or system by detecting changes in orientation and motion (acceleration) (Ancillao A, dkk, 2018). Based on an object's inertial behavior, it provides information on its stability or imbalance by recording changes in direction and rotational speed. In order to filter out noise and provide a clear indication regarding movement or more serious imbalances, sensors can frequently be adjusted for vibrations and small disruptions.

Typically, the sensor is found on the limbs and trunk. The participant's body is equipped with a gadget that uses inertial sensors (Ihsan N, dkk, 2024). Then, through a series of tests, participants were asked to maintain their body's balance. In addition to angular and turn speeds, inertial sensor data is utilized for temporal and spatial-temporal gait metrics.

Biodex balance system:

A cutting-edge tool for evaluating and improving a person's balance, stability, and proprioception is the Biodex Scale System. It is frequently used to assess balance skills and enhance stability in physical therapy, sports training, rehabilitation, and research. Usually, these systems come with a computerized platform that can be adjusted for stability, enabling accurate control and assessment of balancing performance.

Standing on a platform that can be angled up to 20 degrees in any direction is necessary for the Biodex balancing system (Azali FA, 2019). The participant receives visual feedback on the location of their COM in relation to the platform's edge via the LCD screen (Handayani SG, dkk, 2023). A built-in safety handrail and an optional overhead harness system can be fitted if additional support is needed.

Forceplate

The ground reaction force generated by an object or person standing, moving, or interacting with its surface is measured by a force plate, also known as a force platform. Force plates are

frequently used to examine movement patterns, balance, and force application in biomechanics, sports science, physical therapy, and research.

Software on the power plate can examine the scale. COP motion track data (in mm) was gathered for each individual and split into anterior-posterior (AP) and mediolateral (ML) components for analysis (Wang H, Du L, Sun Z., 2023). Forceplates have a reputation for being precise and adaptable. However, because motion analysis can be intricate and context-dependent, they require a steady and regulated environment as well as qualified experts to analyze the data.

Inertial Sensor Based 3D Joint Kinematics Tool

The Inertial Sensor-Based 3D Joint Kinetica Tool is a system that measures and analyzes the angle, movement, and orientation of joints in three dimensions using a worn inertial sensor (IMU) (Santos VM, dkk, 2023). The magnetometer's independent sensor fusion method produced encouraging results from this analysis, displaying no discernible anomalies in the joint angle data. As a result, a standalone system that integrates these algorithms offers the possibility of use in clinical gait analysis and future development. 3D joint kinematics tools based on inertial sensors are invaluable resources in clinical and sports contexts, offering crucial information on joint motion and movement patterns in many contexts.

DISCUSSION

An apparatus called a Sensor-Based Dynamic Balance Tool for Postural Stability Control uses particular sensors to assess and train balance and postural stability. Clinical practice and research require clinical evaluation using established instruments for balance control (Pranoto NW, dkk, 2023). This review demonstrates that there has been a great deal of attention from researchers in recent years. The use of different mechanical tools for training or for assessment in clinical settings is being covered in an increasing number of articles (Alimuddin A, dkk, 2024). The majority of these chosen publications go into the study of their many facets. Estimates indicate that the advantages of measuring balancing results with mechanical equipment are obvious and more trustworthy.

All tools can be divided into three primary groups according to the balancing components they measure. These consist of the following: Static Standing Balance, Static and Dynamic Standing Balance on Platform, Computerized Dynamic Posture and Biodex Balance System, Static and Dynamic Standing Balance with Gait Analysis, Strength Plates and Clinical Sensory Interaction Trials. Some of the aforementioned methods are frequently used in sports, rehabilitation, and biomechanical research to assist people strengthen their posture, increase their ability to balance, and lower their risk of falling.

CONCLUSSION

The Sensor-Based Dynamic Balance Tool for Postural Stability Control is designed to assess and improve balance and postural stability through specialized sensor technology. Accurate clinical evaluation using validated balance control tools is critical in both clinical practice and research. Recent years have seen a surge of interest in this area, as evidenced by a growing number of publications exploring various mechanical tools for assessment and training.

DAFTAR PUSTAKA

Thompson LA, Melendez RAR, Chen J. Investigating Biomechanical Postural Control Strategies in Healthy Aging Adults and Survivors of Stroke. Biomechanics. 2024;4(1):153–64.

Kharbat AF, Ha FLX, Zumwalt M, Robert-McComb JJ. The Importance of Posture and Muscular Balance in the Body for Managing Skeletal Muscle Injuries in Active Females. In: The Active Female: Health Issues throughout the Lifespan. Springer; 2023. p. 211–28.

Ilg W, Milne S, Schmitz-Hübsch T, Alcock L, Beichert L, Bertini E, et al. Quantitative gait and balance outcomes for ataxia trials: consensus recommendations by the ataxia global initiative working group on digital-motor biomarkers. The Cerebellum. 2024;23(4):1566–92.

Lyon MF, Mitchell K, Roddey T, Medley A, Gleeson P. Keeping it all in balance: a qualitative analysis of the role of balance outcome measurement in physical therapist decision-making and patient outcomes. Disabil Rehabil. 2023;45(19):3099–107.

Mahoney J. Subjective well-being measurement: Current practice and new frontiers. 2023;

Buckley C, Alcock L, McArdle R, Rehman RZU, Del Din S, Mazzà C, et al. The role of movement analysis in diagnosing and monitoring neurodegenerative conditions: Insights from gait and postural control. Brain Sci. 2019;9(2):34.

Neville C, Ludlow C, Rieger B. Measuring postural stability with an inertial sensor: validity and sensitivity. Med Devices Evid Res. 2015;447–55.

Ancillao A, Tedesco S, Barton J, O'Flynn B. Indirect measurement of ground reaction forces and moments by means of wearable inertial sensors: A systematic review. Sensors. 2018;18(8):2564.

Ihsan N, Yulkifli Y, Hadi A, Yohandri Y, Mario DT, Ayubi N, et al. Sensor-based scoring system for the fighting category in Pencak Silat. Retos nuevas tendencias en Educ física, Deport y recreación. 2024;(57):684–91.

Azali FA. Postural Stability and Risk of Fall of Person with Trilateral Prosthesis. University of Malaya (Malaysia); 2019.

Handayani SG, Myori DE, Komaini A, Mario DT. Android-based gymnastics learning media to improve handstand skills in junior high school students. 2023;

Wang H, Du L, Sun Z. Optimization design of conical reaction teeth of shear wave vibroseis

vibration plate. Glob Geol. 2023;26(4):264–72.

Santos VM, Gomes BB, Neto MA, Amaro AM. A Systematic Review of Insole Sensor Technology: Recent Studies and Future Directions. Appl Sci. 2024;14(14):6085.

Pranoto NW, Chaeroni A, Rifki MS, Ilham A, Susanto N. The effects of inactivity during the COVID-19 pandemic on the psychomotor skills of kindergarten students. Ann Appl Sport Sci. 2023;11(2):0.

Alimuddin A, Nazri SBM, Liza L, Pebriyani D, Muchlis AP. Physical education and sport essential as transversality and body integration in the learning process: A systematic review. Retos nuevas tendencias en Educ física, Deport y recreación. 2024;(58):20–7.