Clinical Rehabilitation 2000; **14**: 402–406

What is balance?

Alexandra S Pollock, Brian R Durward, Philip J Rowe Department of Physiotherapy, Queen Margaret University College, Edinburgh and **John P Paul** Department of Bioengineering, University of Strathclyde, Glasgow, Scotland

Received 2nd December 1998; returned for revisions 12th August 1999; revised manuscript accepted 9th October 1999.

Balance is a term frequently used by health professionals working in a wide variety of clinical specialities. There is no universally accepted definition of human balance, or related terms. This article identifies mechanical definitions of balance and introduces clinical definitions of balance and postural control. Postural control is defined as the act of maintaining, achieving or restoring a state of balance during any posture or activity. Postural control strategies may be either predictive or reactive, and may involve either a fixed-support or a change-in-support response. Clinical tests of balance assess different components of balance ability. Health professionals should select clinical assessments based on a sound knowledge and understanding of the classification of balance and postural control strategies.

Introduction

Balance is a common term, frequently used by health professionals within a wide variety of clinical specialities. The word balance is often used in association with terms such as stability and postural control. Evaluation of balance is considered to be pertinent to the assessment of many patients, including those with neurological deficits, orthopaedic deficits and vestibular disorders. Despite the widespread use of the term, there is no universally accepted definition of human balance.[1,2] Thus, although it has been argued that therapists have an intuitive understanding of the term,[1] concise definitions are not available.

The production and use of universally accepted definitions of terms used within clinical practice is essential for the accurate and precise assessment, documentation and interpretation of patient problems. The valid definition of clinical terminology is fundamental to the formation of evidence-based practice and to the provision of optimal patient care. This article aims to explore the intuitive understanding of human balance, and to identify concise definitions of balance and related terms.

Mechanical definitions

Balance

The term balance (or equilibrium), as used in mechanics, is defined as the state of an object when the resultant load actions (forces or moments) acting upon it are zero (Newton's First Law).[3] The ability of an object to balance in a static situation is related to the position of the centre of mass (also referred to as the centre of gravity or CoG[4,5]) and the area of the base of support (BoS) of that object.[4] If the line of gravity of an object falls within the BoS of that object then the object is balanced.[3] The object becomes

Address for correspondence: Alexandra S Pollock, Physiotherapy Department, Queen Margaret University College, Duke Street, Edinburgh EH6 8HF, Scotland. e-mail: pollock@middleton4.freeserve.co.uk

0269–2155(00)CR342OA

unbalanced, and will fall, if the line of gravity is displaced out of the base of support.[3] This is illustrated in Figure 1.

Stability

The greater the displacement of the line of gravity before an object becomes unbalanced the greater the stability of that object. Similarly, the greater the external force that can be applied to the object before it becomes unbalanced the greater the stability of that object.[3] Thus, mechanical principles dictate that stability exists if the line of gravity falls within the BoS, and increases with a larger BoS, a lower CoG, or a more central CoG within the BoS.[3]

Human balance

Postural control

The principles of newtonian mechanics and the relationships described between stability, the BoS, the line of gravity and the CoG are equally applicable to the balance of humans (or animals) as they are to inanimate objects. During upright stance, the human body has a relatively high CoG and a relatively small BoS, which complicates the problem of the maintenance of stability.[6,7] For an inanimate object, if the line of gravity falls out of the BoS the force of gravity dictates that that object will fall (or move). However, when, in a human, the line of gravity falls out with the BoS the human body has the inherent ability to sense the threat to stability and to use muscular activity to counteract the force of gravity in order to prevent falling.[8] Thus, a human has control over balance ('balance control' or, more commonly, 'postural control'), while an inanimate object does not.

Postural control is a prerequisite to the maintenance of a myriad of postures and activities. However, the control of balance has been identified to be associated with three broad classes of human activity[9,10]:

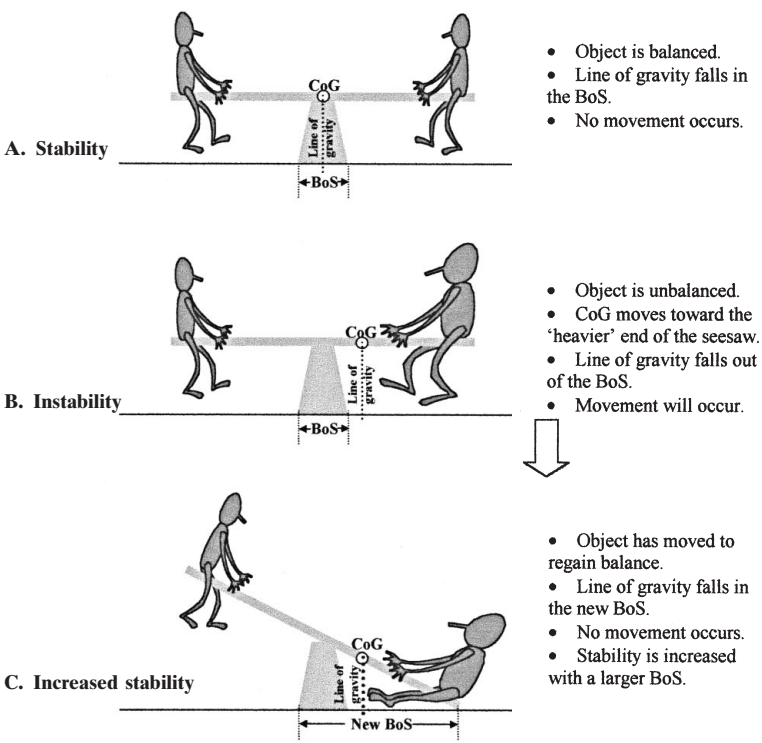

Figure 1 Relationship between base of support (BoS), line of gravity and stability.

1) The maintenance of a specified posture, such as sitting or standing
2) Voluntary movement, such as the movement between postures
3) The reaction to an external disturbance, such as a trip, a slip or a push.

These classifications encompass the acts of maintaining, achieving or restoring the line of gravity within the BoS.

The mechanical definition of stability refers to the 'inherent ability' of an object to remain in or return to a state of balance, with the 'inherent ability' referring to the physical properties of the object, such as the position of its CoG relative to the BoS. Human stability can be defined as the 'inherent ability' of a person to maintain, achieve or restore a state of balance, but in this case the 'inherent ability' encompasses the sensory and motor systems of the person,[8,11] in addition to the physical properties of the CoG and BoS. Maki and McIlroy[7] described 'balance control' as the ability to regulate the relationship between the line of gravity and the BoS during activities of daily life. Postural control can therefore be defined as the act of maintaining, achieving or restoring a state of balance during any posture or activity.

Strategies of postural control

Postural control strategies may be either 'reactive' (compensatory) or 'predictive' (anticipatory), or a combination of both.[7] A predictive postural control strategy might involve a voluntary movement, or increase in muscle activity, in anticipation of a predicted disturbance; while a reactive postural control strategy would involve a movement or muscular response following an unpredicted disturbance. These responses may be 'fixed-support', where the line of gravity is moved but the BoS remains unaltered, or 'change-in-support', were the BoS is moved so that the line of gravity intersects it.[7] Swaying from the ankle or hip ('ankle strategy' or 'hip strategy')[8,12,13] are commonly described fixed-support strategies, while grasping with a hand or stepping ('stepping strategy')[8,12] are common change-in-support strategies.

Although postural control strategies have traditionally been considered as reflex-like responses elicited automatically by a sensory stimulus, it is now considered that postural responses to maintain balance are reliant on the assessment and control of many variables by the CNS.[14] Strategies of postural control therefore vary depending on an individual's goals and environmental context. This view of postural control implies that balance control can be considered to be a fundamental motor skill learnt by the CNS.[14] Thus, like any other motor skill, postural control strategies can become more efficient and effective with training and practice.[14] Postural control can therefore be regarded as a complex motor skill integral to human posture and movement.

Clinical implications

The observation or assessment of a dysfunction in the ability of a patient to maintain, achieve or restore a state of balance implies a deficit in postural control. Any cognitive, sensory or motor impairment can result in a postural control deficit. Awareness of the different classifications of activities requiring postural control, and the different postural control strategies, should assist in the accurate and precise assessment, diagnosis, documentation and interpretation of balance problems, and lead to improved patient care.

There are a large number of clinical assessments of human balance. These assessments can provide information on a variety of different aspects of postural control. For example, the Rivermead Stroke Assessment[15] tests the ability of a patient to sit unsupported (i.e. maintain a posture); the Motor Assessment Scale (MAS)[16] tests the ability of a sitting patient to perform a voluntary movement (i.e restore a posture following a predictable disturbance) and to move from sitting to standing (i.e. achieve a new posture); while Sandin and Smith[17] describe a test that requires a sitting patient to respond to a lateral push to the trunk (i.e. restore a posture following an unpredicted disturbance). While each of these clinical tests are valid assessments of a patient's balance, each test is assessing a different aspect of postural control. Rather than an arbitrary selection of an assessment, knowledge pertaining to the classification of balance and postural control strategies should be used to select a clinical assessment – or assessments – rel-

evant to each individual patient or medical condition.

Conclusions

The concepts of balance and human movement are integral and fundamental to rehabilitation in a wide variety of clinical specialities. Clear and concise, universally accepted definitions of balance should therefore be central to clinical practice. The mechanical concepts and ideas presented in this article will not be new to the majority of health professionals who are regularly involved in the assessment and treatment

Clinical messages

- Postural control refers to the act of maintaining, achieving or restoring the line of gravity within the BoS.
- Postural control strategies may be predictive or reactive, and involve fixed-support or change-in-support responses.
- Clinical assessments of human balance may test different aspects of postural control.
- Relevant assessments should be selected based on a knowledge and understanding of balance and postural control.

Table 1 Definitions of balance, human balance and related terms

Term	Definition
Balance	The state of an object when the resultant force acting upon it is zero.[3]
Human balance	A multidimensional concept, referring to the ability of a person not to fall.[1,6]
Centre of gravity (CoG)	The point through which the vector of total body weight passes.[18]
Line of gravity	A vertical line running through the CoG.[3]
Base of support (BoS)	The area of the single contact between the body and support surface or, if there is more than one contact with the support surface, the area enclosing all the contacts with the support surface.[4]
Stability	The inherent ability of an object to remain in or return to a specific state of balance and not to fall. The inherent ability referring to the physical properties of that object.
Human stability	The inherent ability of a person to maintain, achieve or restore a specific state of balance and not to fall. The inherent ability referring to the motor and sensory systems and to the physical properties of the person.
Postural control	The act of maintaining, achieving or restoring a state of balance during any posture or activity.

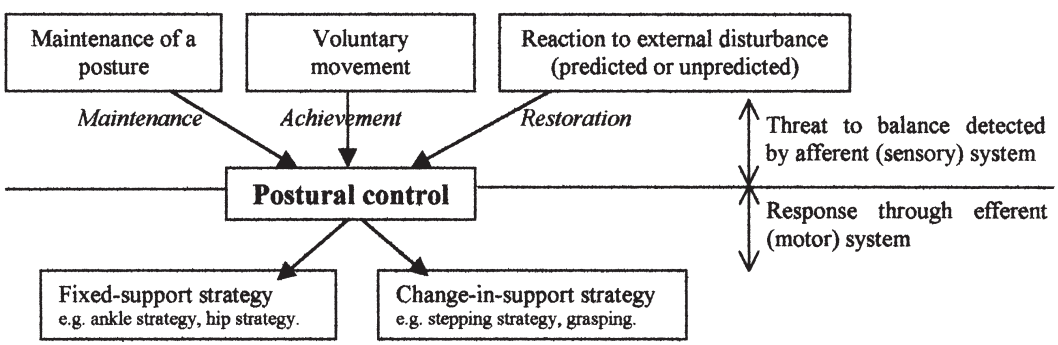

Figure 2 Classes of function requiring postural control and postural control strategies.

of patients with problems relating to the maintenance of balance. However, in the clinical environment the understanding of balance and postural control has been largely intuitive and assessment, documentation and treatment have lacked a systematic approach. This article identifies simple clinical definitions of balance and postural control, which are summarized in Table 1, and outlines the concept of postural control strategies (Figure 2). It is proposed that these definitions are universally appropriate and that use of these terms, as explained in this article, will assist individual patient care and will promote scientific evaluation of clinical practice.

References

1 Berg K. Balance and its measure in the elderly: a review. *Physiother Can* 1989; **41**: 240–46.
2 Ekdahl C, Jarnio GB, Andersson SI. Standing balance in healthy subjects. *Scand J Rehabil Med* 1989; **21**: 187–95.
3 Bell F. *Principles of mechanics and biomechanics*. Cheltenham: Stanley Thornes, 1998.
4 Hall S. *Basic biomechanics*. St Louis: Mosby Year Book, 1991.
5 Kreighbaum E, Barthels KM. *Biomechanics: a qualitative approach for studying human movement*. New York: Macmillan, 1990.
6 Winter DA. Human balance and posture control during standing and walking. *Gait Posture* 1995; **3**: 193–214.
7 Maki BE, McIlroy WE. The role of limb movements in maintaining upright stance: the 'change-in-support' strategy. *Phys Ther* 1997; **77**: 488–507.
8 Horak FB. Clinical measurement of postural control in adults. *Phys Ther* 1987; **67**: 1881–85.
9 Berg K, Wood-Dauphinee S, Williams J, Gayton D. Measuring balance in the elderly: preliminary development of an instrument. *Physiother Can* 1989; **41**: 304–11.
10 King MB, Judge JO, Wolfson L. Functional base of support decreases with age. *J Gerontol* 1994; **49**: M258–63.
11 Nashner LM. Adaptation of human movement to altered environments. *Trends Neurosci* 1982; **5**: 358–61.
12 Duncan PW, Studentski S, Chandler J, Bloomfield R, LaPointe LK. EMG analysis of postural adjustments in two methods of balance testing. *Phys Ther* 1990; **70**: 88–96.
13 Horak FB, Nashner LM. Central programming of postural movements: adaptation to altered support surface configurations. *J Neurophysiol* 1986; **55**: 1369–81.
14 Horak FB, Henry SM, Shumway-Cook A. Postural perturbations: new insights for the treatment of balance disorders. *Phys Ther* 1997; **77**: 517–33.
15 Lincoln N, Leadbitter D. Assessment of motor function in stroke patients. *Physiotherapy* 1979; **65**: 48–51.
16 Carr JH, Shepherd RB, Nordholm L, Lynne D. Investigation of a new motor assessment scale for stroke patients. *Phys Ther* 1985; **65**: 175–80.
17 Sandin KJ, Smith BJ. The measure of balance in sitting in stroke rehabilitation. *Stroke* 1990; **21**: 82–86.
18 Braune W, Fischer O. *On the centre of gravity of the human body*. New York: Springer-Verlag, 1985.