

Manual examination of accessory movements—seeking R1

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Movement diagrams are used by physiotherapists to depict the behaviour of resistance through the available range of accessory and physiological joint movement. It is generally accepted that for an asymptomatic joint, the resistance first felt by the therapist (R1) occurs towards the end of range. R1 is considered to be at the transition point between the toe and linear region of a load displacement curve. The aim of this study was to more accurately define R1 from force displacement curves of accessory movement to the spine and peripheral joints using a validated instrument, the Spinal Assessment Machine (SAM). Thirty archived force displacement curves obtained using the SAM, which applied a posteroanterior force of 100N at a frequency of 0.5 Hz to L3 spinous process, were examined. In addition force displacement curves were similarly obtained from the tibiofemoral joint, glenohumeral joint and radiocarpal joint of one asymptomatic individual. In all cases resistance to a PA movement commenced at the beginning of range, the curve ascending as soon as the force was applied. While in most cases there was a low stiffness 'toe' region there was no unambiguous point where it could be said that the toe region ended. It is concluded that for spinal and peripheral accessory movements both the onset of resistance and the toe occurs at the beginning of range. Therapists should therefore depict R1 at the beginning of range not toward the end of range as is current practice.

INTRODUCTION

Physiotherapists use movement diagrams during joint examination to describe the behaviour of pain, resistance and/or muscle spasm when a force is manually applied to a peripheral or spinal joint. Maitland originally developed these diagrams in 1970 as a teaching aid and as a means of communication between therapists for recording the examination of both accessory and physiological joint movement. To complete a movement diagram the therapist passively

moves the joint through the range and feels the resistance to movement, the onset of any possible muscle spasm and determines from the patient the behaviour of any existing pain. As soon as the therapist applies a force, physical laws dictate that there will be an equal and opposite force from the joint, but this resistance to movement is considered to be minimal and imperceptible to the therapist and is to be ignored when drawing a movement diagram (Magarey 1984, Maitland et al. 2001). A normal joint is thus described as having a resistance-free range where the joint surfaces glide like 'wet soap sliding on wet glass' (Maitland et al. 2001, p. 439), and hence the first point of resistance felt by the examiner (R1) is depicted at some point along the AB line (Fig. 1) towards the end of range. R2 is described as the maximum resistance into which the therapist is prepared to push (Magarey 1985, Maitland et al. 2001) and is thought to represent the end of the range of joint movement. The BD line of the movement diagram lies at the end of range and is depicted as a thick line (Fig. 1) to allow for the inevitable variation between therapists in their judgement regarding end of range (Magarey 1985).

Having examined a symptomatic joint and drawn a movement diagram the therapist then chooses a

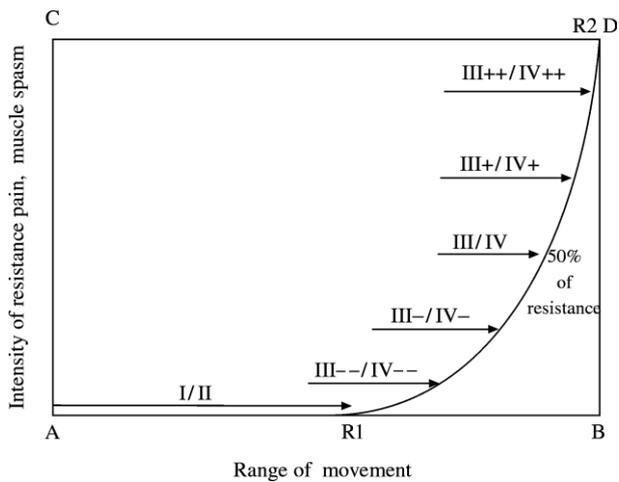


Fig. 1 Movement diagram with grades of movement related to various percentages of resistance curve (Magarey 1984, 1985). Where: A is the beginning of range; B is the end of range; AC line is the intensity of pain, resistance and muscle spasm; R1 is the first point of resistance felt by the therapist; R2 is the maximum resistance to which the therapist is prepared to push.

Grade of Movement with which to treat the joint. The choice of Grade will depend on the intensity and relationship of pain and resistance through the range of movement available, as well as the presence of any muscle spasm. The grade of movement is related to the perceived resistance to the movement (Magarey 1984; 1985; Maitland et al. 2001), Grades I and II being short of R1, Grades III and IV occurring after R1 (Fig. 1).

Research into the reliability of therapists to judge stiffness (R1 and R2) has largely focused on accessory movements to the spine; the majority of studies have investigated judgement of stiffness when examining posteroanterior (PA) central vertebral pressures to the lumbar spine. These studies can be broadly divided into those that have used a palpation simulator, and those that have used human spines (in both asymptomatic and symptomatic subjects). Only a few studies have concluded good reliability: one using a simulator (Trott et al. 1989) and three using a spine (Jull & Bullock 1987; Minucci 1987; Jorgensson 1993). In contrast, the majority of studies carried out on human spines have found poor intra- and inter-therapist reliability (Matyas & Bach 1985; Viner et al. 1991; Binkley et al. 1995; Maher & Adams 1994; Lindsay et al. 1995; Phillips & Twomey 1996). It is not surprising then that the performance of 'resistance-defined' grades of movement has also been found to be unreliable. Poor reliability was found when the grades were performed on a simulator (Hardy & Napier 1991, Simmonds et al. 1995) and on a human spine (Matyas & Bach 1985; Harms & Bader 1997).

One of the possible explanations for the poor reliability of therapists to detect resistance during

spinal joint accessory movement may relate to the concept of R1. The resistance described in a movement diagram has been related to the load displacement curves of connective tissue (Lee & Evans 1994; Maitland et al. 2001). Lee & Evans (1994) consider R1 to be the transition point between the toe region where resistance is imperceptible to the therapist, and the linear region where there is a sharp inflexion of the force displacement curve (Fig. 2). It can be seen in Figure 2 that there is no one single transition point between the toe and linear regions of the force-displacement curve, rather there are a range of points which might be considered to reflect a change in gradient. The studies which have tested therapist reliability of finding R1 or applying Grades of Movement just prior to or after R1 (Matyas & Bach 1985; Harms & Bader 1997) have used force as a measurement. This method is invalid if there is no one point of inflexion of the resistance curve. For example one therapist may apply 20N to reach R1, while another therapist may use 25N. This difference in force would be considered to reflect poor reliability in previously published studies; however if R1 were to be more accurately defined as a section of the curve between 20 and 30N force then the therapists would have been considered to be reliable.

The concept of resistance through range as depicted on a movement diagram has to date been based on a theoretical model; more recently, equipment has become available which enables the resistance through range to be quantified. The purpose of this present study was to define the normal force displacement curve of a clinically defined accessory movement applied in vivo to the spine and to peripheral joints, using a validated instrument, the Spinal Assessment Machine (SAM).

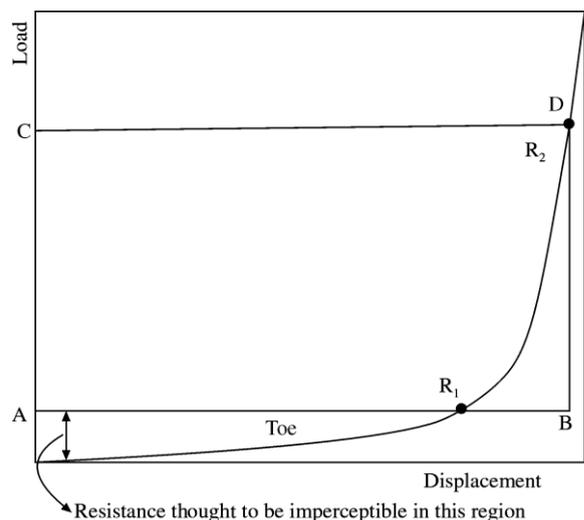


Fig. 2 Relationship of movement diagram (ABCD) to load-displacement curve. (Reproduced by kind permission from Lee R, Evans J 1994 Towards a better understanding of spinal postero-anterior mobilisation *Physiotherapy* 80: 68-73).

The aim was then to more accurately define R1 as a section of the force displacement curve.

METHOD

Thirty archived force displacement curves obtained from asymptomatic subjects were examined. These curves were originally obtained by Latimer et al., (1996a,b) applying an oscillatory posteroanterior force of around 100N at a frequency of 0.5 Hz to L3 spinous process using the Stiffness Assessment Machine (SAM). This machine has demonstrated accuracy in measuring forces and displacement (Latimer et al. 1996c).

For this present study force-displacement curves were also obtained for accessory movements to three peripheral joints, the tibiofemoral joint, glenohumeral joint and radiocarpal joint. The force-displacement data were obtained with the SAM, by applying a force of around 100 N at a frequency of 0.5 Hz, to the peripheral joints of one asymptomatic subject.

Each curve was visually inspected by two observers (NJP and CM) in an attempt to identify a change in the gradient of the curve from a toe region to a linear region. If no clear point of inflexion occurred, an attempt was then made to identify a section of the curve depicting the greatest change in resistance, that

is a range of points, which might be considered to represent the change between the toe and linear region of the curve.

RESULTS

In all cases resistance commenced at the beginning of range, the curve ascending as soon as the force was applied. Figure 3 is a typical example of a force-

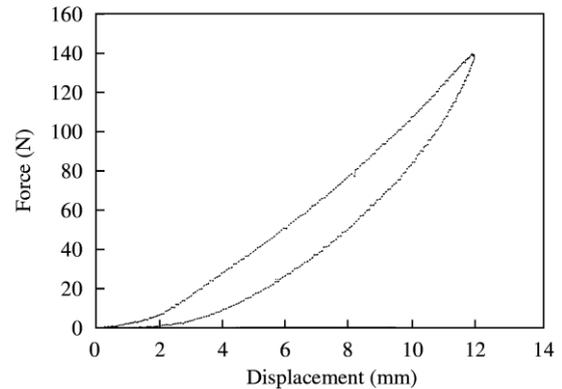


Fig. 3 Typical force-displacement curve of a central PA applied to L3 obtained using the SAM. The left hand curve is loading and the right hand curve is unloading curve.

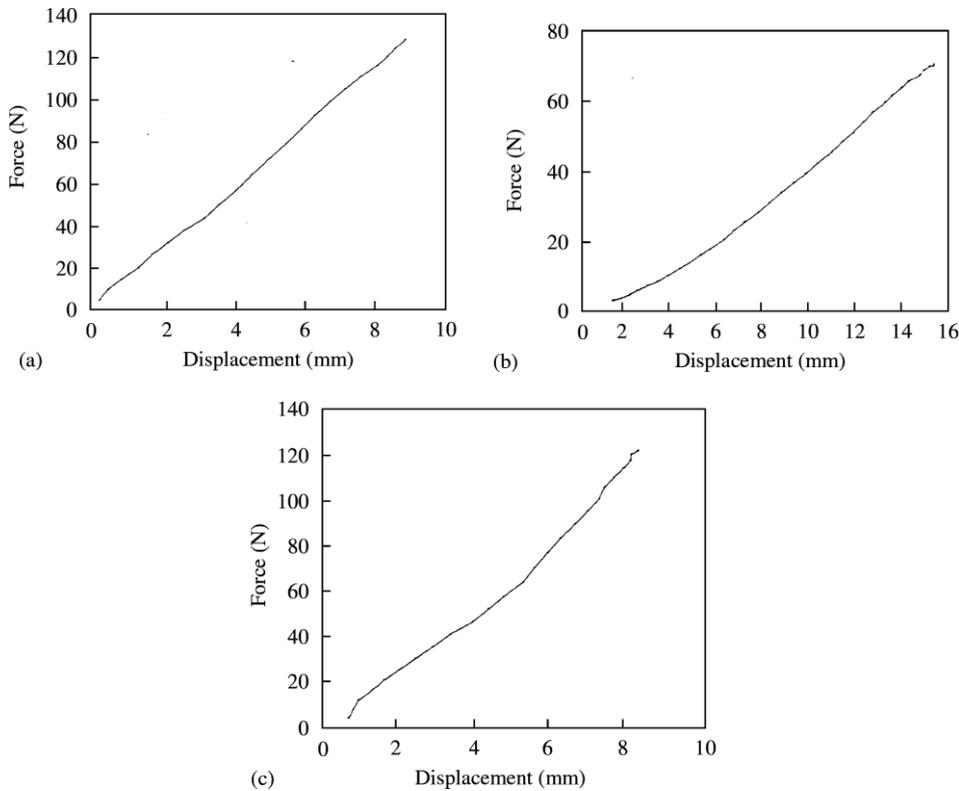


Fig. 4 Force-displacement curves obtained for accessory movement of peripheral joints, (A) when an AP force is applied to the tibiofemoral joint on the tibia with the knee in slight flexion, (B) when an AP force is applied to the glenohumeral joint on the head of the humerus with the glenohumeral joint in some abduction, (C) when a PA force is applied to the wrist joint on the radius.

displacement curve obtained by applying a central PA force to the lumbar spine. Figure 4 demonstrates the force-displacement curves obtained by applying an accessory movement to the three peripheral joints. Figure 4A depicts a force-displacement curve obtained when a PA force is applied to the tibiofemoral joint on the tibia. Figure 4B demonstrates a force-displacement curve obtained in response to application of an anteroposterior (AP) force to the glenohumeral joint on the head of the humerus, while Figure 4C is the force-displacement curve obtained for a PA force to the radiocarpal joint on the radius.

In all cases there was no clear inflexion of the force-displacement curve, either as a single point or as a range of points.

DISCUSSION

The results clearly demonstrate that for both spinal and peripheral accessory movements resistance begins immediately force is applied. Several previous studies investigating force-displacement curves for both spinal accessory movements (Lee & Svensson 1990; Lee & Evans 1992; Latimer et al. 1996d, 1997) and peripheral accessory movements (Yoon & Mansour 1982; Clark et al. 1987; Luster et al. 1990; Watson & Andrews 1991; Skalley et al. 1993; Fithian et al. 1995; Maitland & Kawchuk 1997) have also shown that resistance occurs immediately the testing force is applied. This is not surprising as it follows the physical law that when a force is applied there is an equal and opposite force.

The results of this study challenge the view put forward by Lee & Evans (1994) that the movement diagram is analogous to a load-displacement curve (Fig. 1). While Lee & Evans (1994) depict load displacement curves with a clear transition point between the toe and linear regions of the force displacement curve, the force displacement curves obtained in this current study (Figs 3 and 4) demonstrate toe regions where there was no clear transition point between the toe and linear regions with which to define R1. The poor reliability of therapists to judge resistance may, in part, be due to this discrepancy and may account for poor reliability in the use of the resistance based grading system suggested by Magarey (1984, 1985) and Maitland et al. (2001).

The results of this study show that resistance comes on immediately force is applied and gradually increases as the movement progresses through range. It may be helpful for therapists to consider this behaviour of resistance when examining spinal and peripheral accessory movements. In theory, since resistance starts at the beginning of the range, R1 could be notated here, that is at A of the movement

diagram. Therefore Grade I and II movements would not be possible within a movement notation system where these Grades are defined as movement prior to the onset of resistance. The only possible treatment Grades of movement (defined in relation to resistance) would be Grades III or IV. However for physiotherapists who use Maitland's original grading system, that does not consider resistance, Grades I and II would still be possible.

The force displacement curves observed in this study have been produced with PA forces up to 100N, yet therapists have been known to apply forces of up to 329N (Matyas & Bach 1985) when applying spinal PA mobilizations. The slope of the resistance curve however, becomes more curvilinear with higher forces up to 250N (Lee et al. 1997; Nicholson et al. 2001) and is therefore consistent with the findings of this study.

The shape and slope of the resistance curve may change in the presence of pain and pathology. This study was limited to asymptomatic subjects but in the presence of instability for example, the resistance curve may be quite different. Future studies would be useful to clarify the shape and slope of the resistance curve in patients with various spinal and peripheral joint dysfunctions.

CONCLUSION

Published movement diagrams in manual therapy texts are quite unlike the objective force-displacement curves obtained from in-vivo testing using a validated instrument. For spinal and peripheral accessory joint movement, resistance occurs at the beginning of range and increases in a linear fashion. It is suggested that for movement diagrams illustrating accessory movements of the spine and peripheral joints, R1 may be depicted as early as A and the choice of resistance-defined treatment Grades of Movement would, as a consequence, be limited to III's (III-, III, III+) and IV's (IV-, IV, IV+) only.

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