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Use of the phrase 'pyramidal weakness' within the past 100 years

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ABSTRACT

The concept of 'pyramidal weakness' denotes that neurological examination findings can be localised to the central nervous system (CNS), and implying a specific pattern of motor weakness involving upper limb extensors and lower limb flexors. However, other weakness patterns have been observed in CNS lesions. We aim to investigate the pattern of weakness observed in CNS lesions and explore the use of the phrase 'pyramidal weakness' over time. We searched Medline, PubMed, and Google Scholar up to January 1st, 2022, using keywords such as 'distal weakness,' 'upper limb flexion,' 'lower limb extension,' 'pyramidal weakness,' and related terms. The inclusion criteria were papers relating to brain or spinal cord lesions and terms inferring their presence or the description of a motor weakness pattern. We identified 117 studies since 1889, of which 29.9% of publications described weakness in upper limb extensors and lower limb flexors, and 26.5% reported distal weakness. We found an early reference to 'pyramidal weakness' in 1922 in the context of unilateral weakness in encephalitis with no description of the upper limb extensor and lower limb flexor pattern. Since 1988, 'pyramidal weakness' has become associated with weakness in upper limb extensors and lower limb flexors. The phrase 'pyramidal weakness', used in its current format, has been more frequent since the 1980s. Distal weakness and upper limb extensor and lower limb flexor weakness have been associated with CNS lesions.

INTRODUCTION

The phrase upper motor neuron (UMN) syndrome has been used to infer a central nervous system (CNS) lesion affecting the motor tracts of the brain or spinal cord.[1] Clinical examination findings such as motor weakness, clonus, increased reflexes and tone serve as indicators of this syndrome.[1] Lesions leading to the UMN syndrome are implied by expressions including 'pyramidal weakness' and 'pyramidal sign'.[2] An understanding of motor weakness in the UMN syndrome is useful when examining patients and localising CNS lesions.

Motor weakness in upper limb extensors and lower limb flexors has been associated with the terms 'pyramidal weakness' and 'pyramidal signs'.[3–5] This definition is found in neurology textbooks and, as such, is used in that context by many physicians.[6 7] However, researchers employing dynamometry to measure muscle strength have observed variations in motor weakness in the context of stroke. These findings included a pattern of distal motor weakness defined by movements of the fingers and toes being weaker than movements at the proximal joints.[8–11] It is important to explore the pattern of weakness in the UMN syndrome as neurology trainees study this concept to assist in the localisation of brain and spinal cord lesions. We aim to investigate the pattern of motor weakness observed in CNS lesions and explore the use of the phrase pyramidal weakness over time. Understanding this term may assist clinicians in localising CNS lesions.

METHODS

Search strategy

Medline, Embase and Google Scholar were searched for studies published in all languages until 1 January 2022. This search aimed to capture peer-reviewed articles describing the pattern of motor weakness observed in CNS lesions. The ensuing search strategy was implemented for title and abstract screening in the Medline database: "pyramidal weakness".ti,ab. OR "distal weakness".ti,ab. OR "pyramidal sign".ti,ab. OR "pyramidal tract sign".ti,ab. OR "pyramidal syndrome".ti,ab. OR "sign of pyramidal lesion".ti,ab. OR "sign of pyramidal disease" .ti,ab. OR "sign of pyramidal involvement".ti,ab, OR "upper limb flexion".ti,ab. OR "lower limb extension" .ti,ab. Embase and Google Scholar search strategies were also recorded (online supplemental appendix 1). The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram is provided in figure 1.

Study selection

The inclusion criteria were papers relating to brain or spinal cord lesions and terms inferring their presence or the description of a motor weakness pattern. All types of literature were eligible for consideration

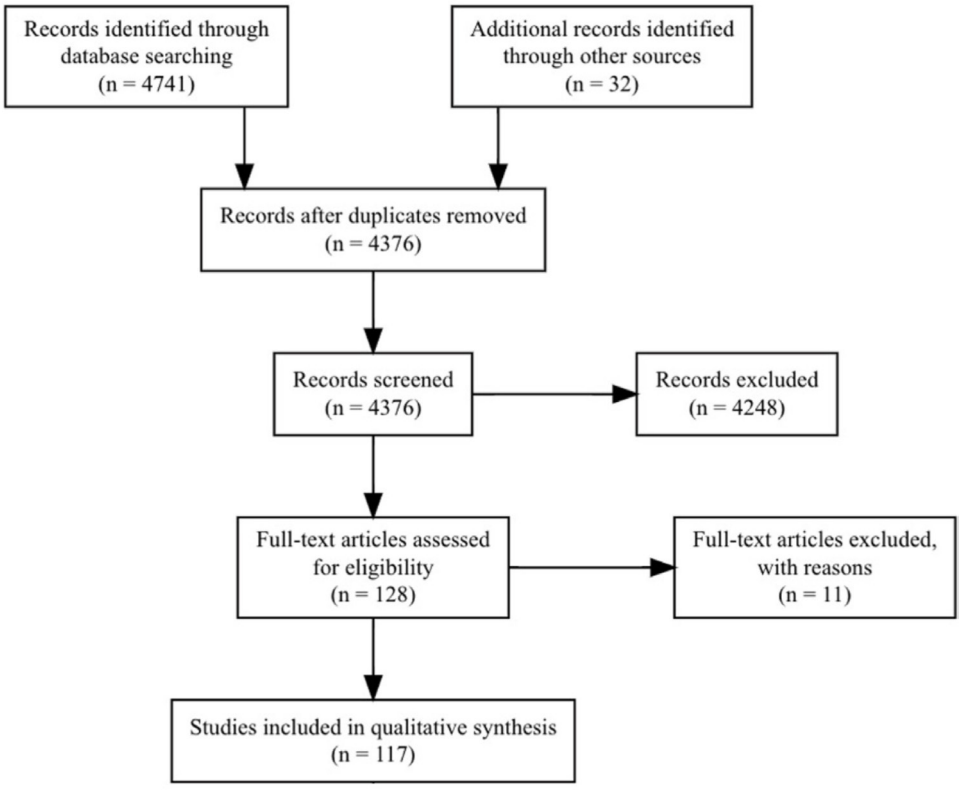

Figure 1 Preferred Reporting Items for Systematic Reviews and Meta-Analyses flow diagram illustrating record identification, screening and inclusion.

and article selection was not limited to the human evidence base or by language of text. Authors conducted title and abstract screening using Covidence (online supplemental appendix 2). Texts were excluded if they did not relate to CNS lesions, or where they failed to describe at least one of the search terms and motor weakness patterns within the title or abstract. Articles that could not be retrieved, even with the assistance of a Monash Health librarian, were also excluded (see PRISMA diagram in figure 1).

Data extraction and statistical analysis

The variables extracted included literature type, year of publication and the frequency of the phrases: *pyramidal weakness* and *distal weakness*. We noted the motor weakness patterns described in individual articles, encompassing distal weakness or motor weakness in upper limb extensors and lower limb flexors. Term frequency across full texts was recorded as a binary outcome, with 1 indicating 'present in the publication' and 0 indicating 'not present in the publication'. This binary approach was also applied to the identified patterns of motor weakness mentioned earlier. Descriptive analysis of terms and motor weakness patterns within the obtained literature was performed. The ggplot2 library in the R statistical foundation (V.4.12) was employed to generate a frequency table and a time-series plot of search terms and motor weakness patterns.

RESULTS

The title and abstract search retrieved 4376 articles, where 4248 records were excluded after applying exclusion criteria and removing duplicated texts. Eligible literature for full-text analysis comprised 128 publications. Despite efforts aided by a Monash Health librarian, 11 studies could not be retrieved and were subsequently excluded from analysis. A total of 117 publications met the inclusion criteria and were analysed in full text, where these texts related to stroke, brain and spine tumours, primary lateral sclerosis or syringomyelia (figure 1). Motor weakness in upper limb extensors and lower limb flexors was referenced in 29.9% of publications, showing an increased frequency of use from 1889 to 2021 (figures 2 and 3). Between 1900–1920 and 1960–1980, an increase in the number of publications describing upper limb extensor and lower limb flexor weakness was observed, where these years exhibited 5 and 11 publications describing this pattern, respectively (figure 3). Approximately 12% of the literature described weakness in upper limb extensors and lower limb flexors without mentioning distal weakness (online supplemental file 1). Distal weakness was described in 26.5% of studies showing an increased use over time (figures 2 and 3). This pattern was initially observed between 1880 and 1900 and was exhibited in two publications. However, a distal weakness pattern was predominately found between 1960 and 1980, shown in 12 publications (figure 3). Distal weakness

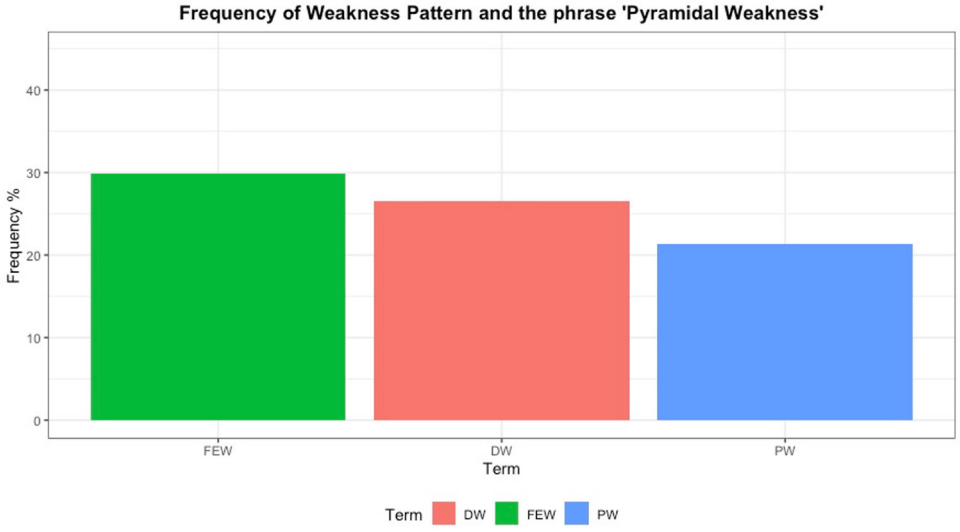

Figure 2 Frequency of weakness pattern and the phrase 'pyramidal weakness' among analysed literature. DW, distal weakness; FEW, upper limb extensor and lower limb flexor weakness; PW, pyramidal weakness.

without mention of weakness in upper limb extensors and lower limb flexors was outlined in 8.5% of articles (online supplemental file 1). Both patterns were present in 17.9% of articles, while neither was evident in 61.5% of studies (online supplemental file 1). The term pyramidal weakness was present in 21.4% of texts, showing an increased use since 1922 (figures 2 and 3). The phrase was found in one publication between 1900 and 1940, and was most frequently used between 1960 and 1980, observed in 10 publications (figure 3). We found an early reference to pyramidal weakness in 1922 in the context of unilateral weakness in encephalitis with no description of the upper limb extensor and lower limb flexor pattern. An early interpretation of pyramidal weakness to mean motor weakness in upper limb extensors and lower limb flexors was in 1988; prior to this, articles used the term in a general sense to indicate the presence of a UMN lesion. No papers in our search used the phrase pyramidal weakness to infer a distal weakness pattern.

DISCUSSION

The primary finding of this study is that the phrase pyramidal weakness dates to the early 20th century and exhibits a varied use across time. A distal weakness pattern has also been observed as a feature of the UMN syndrome. The subsequent paragraphs will discuss the motor weakness patterns that have been observed in CNS lesions, and the use of the term pyramidal weakness over time.

Upper limb extensor and lower limb flexor motor weakness

Motor weakness in upper limb extensors and lower limb flexors is frequently used to indicate UMN lesions (figure 2 and online supplemental file 1). An early

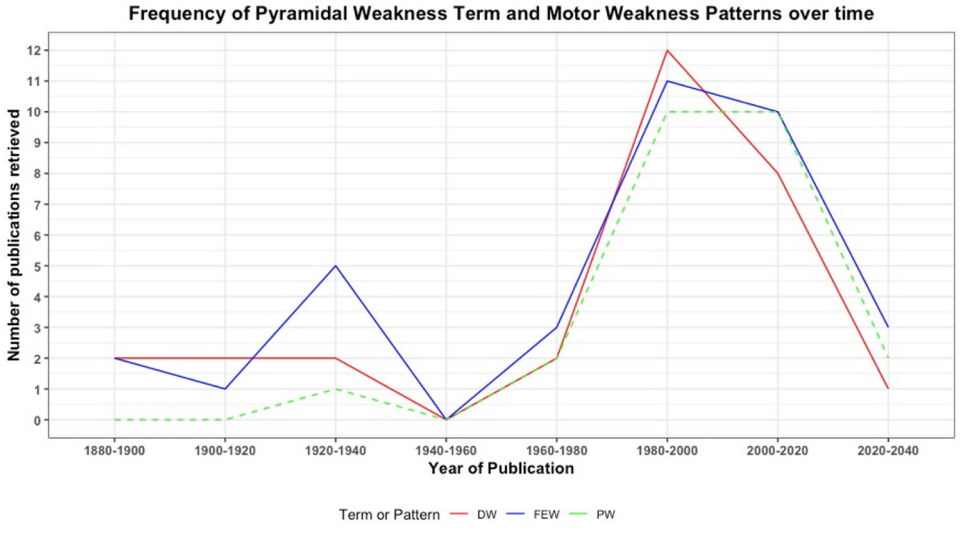

Figure 3 Frequency of 'pyramidal weakness' term and motor weakness patterns over time across analysed literature. DW, distal weakness; FEW, upper limb extensor and lower limb flexor weakness; PW, pyramidal weakness.

reference to the upper limb flexor and lower limb extensor weakness pattern was by Wernicke[12] (1889) and Mann (1895).[13] They gave the description that following UMN lesions, 'in the upper limb there is a restitution in such a way that flexion is more powerful' and in the lower limb, 'the muscle complex which serves for extension is usually intact' (figure 3).[12 13] Similarly, other authors have described motor weakness in the context of cerebral infarction, characterised by 'upper limb flexion and lower limb extension at all joints'.[14 15] Likewise, Brain (1927) cited cases of hemiplegic posturing following UMN lesions, where patients exhibited a 'flexor posture of the upper limb with an extensor attitude of the lower limb'.[16] Many other papers recognise this pattern to localise CNS lesions.[17–20] Upper limb extensor and lower limb flexor weakness may be an unreliable examination finding.[8 9 21] Thijs *et al*[21] conducted a study examining patients with weakness of both central and peripheral origin, using dynamometers to observe the pattern of motor weakness. Their research indicated no significant difference in 'the ratios of flexor/extensor strength at the knee, elbow, and wrist'. The study proposes that the 'traditional notion about the distribution of weakness in UMN lesions may be explained by an intrinsically greater strength in anti-gravity muscles'. Similar findings are evident in related research, where a 'tendency for distal muscles' to be affected is observed.[8 9] Given the dynamometric evidence, the upper limb extensor and lower limb flexor weakness pattern may be unreliable when used to localise CNS lesions.[22]

Distal motor weakness

Distal weakness is observed as a motor presentation of CNS lesions (online supplemental file 1 and figure 3). An early description of this pattern was found in Gowers' 'Manual of Diseases of the Nervous System: Second Edition (1892)', which stated that the loss of power is 'greater towards the extremity of each limb than in the part nearest the trunk' in the context of brain or spinal cord lesions.[23] Likewise, Brain's 'Diseases of the Nervous System First Edition (1933)' shares this view, which mentions how following pyramidal lesions, the 'movements of the fingers and toes are weaker than movements at the proximal joints'.[11] Similar findings are reported in the context of brain and spinal cord lesions, congenital malformations, cerebral trauma, multiple sclerosis and stroke.[13 18 19 24] As distal weakness is discussed alongside upper limb extensor and lower limb flexor weakness across time (figure 3), distal weakness may be an overlooked motor presentation of brain or spinal cord lesions. Considering distal weakness as a feature of the UMN syndrome will broaden a clinician's search for CNS lesions beyond a singular motor weakness pattern.

Many papers did not describe distal or upper limb extensor and lower limb flexor weakness (online supplemental file 1). This can be illustrated in a study of extramedullary tumours causing spinal cord compression, where authors discuss that pyramidal weakness results in an 'increase of the deep reflexes and diminution or loss of the abdominal reflexes' without specifying a motor weakness pattern.[2] Literature that does not describe a weakness pattern may be attributed to included studies exploring other localising signs of CNS lesions beyond motor weakness.

Variation in pyramidal weakness over time

The phrase pyramidal weakness varies in its use over time. The earliest paper in our search to associate pyramidal weakness to weakness in 'extensors in the upper extremity and flexors in the lower extremity' was found in 1988 in the context of cerebral infarcts.[25] The association of pyramidal weakness with this pattern is also observed in literature published throughout the 21st century.[6 7] Variation in the use of the term was observed in the context of unilateral weakness in encephalitis in 1922, with a reference to 'pyramidal weakness of the left side of the body' (figure 3).[26] The term was used in a general manner to indicate UMN disturbance, without mention of weakness in upper limb extensors and lower limb flexors.[26] In patients with spinal cord compression, authors have employed the phrase in a general sense to mean weakness in the 'lower extremities and partially in upper extremities', varying from its current format of use.[2] Similar variation in the use of the phrase pyramidal weakness is observed in the setting of multiple sclerosis, meningitis, stroke and brain or spinal cord lesions.[27–31]

The phrase pyramidal weakness should infer a distal weakness pattern. As 17.9% of articles described distal weakness alongside an upper limb extensor and lower limb flexor pattern to indicate the UMN syndrome, the localisation of CNS lesions may be improved if distal weakness is considered (online supplemental file 1). Given the evidence of distal weakness as a feature of CNS lesions and the varied use of the phrase pyramidal weakness, this phrase should also infer a distal weakness pattern. This understanding will enable neurological trainees to expand their search for CNS lesions and improve their diagnostic formulation by looking for an additional motor presentation.

Limitations

Limitations of this study include its retrospective nature and a small number of included studies. Out of the 117 publications analysed, only 3 contested the reliability of the upper limb extensor and lower limb flexor motor weakness pattern. The small number of articles within our analysis may limit our interpretation of the reliability of this pattern. It should be noted that motor weakness is just one among various clinical signs that assist the localisation of CNS lesions, including increased muscle tone and reflexes, spasticity and clonus.[3]

Conclusion

A pattern of distal weakness and upper limb extensor and lower limb flexor weakness have been associated with CNS lesions. There is a varied understanding of 'pyramidal

weakness' across time; this phrase should also infer a pattern of distal weakness. This understanding will enable neurology trainees to improve their localisation of CNS lesions by considering additional motor presentations.

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