Limb heaviness: a perceptual phenomenon associated with post-stroke fatigue?

Annapoorna Kuppuswamy PhD, Ella Clark MSc, John Rothwell PhD, Nick Ward MD

Sobell department of motor neuroscience, Institute of Neurology, WC1N 3BG

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Corresponding author

Annapoorna Kuppuswamy

33, Queen Square

WC1N 3BG

a.kuppuswamy@ucl.ac.uk

Abstract

Post-stroke fatigue and limb heaviness are two perceptual problems that commonly occur after stroke. Previous work suggests post-stroke fatigue may be related to altered sensorimotor processing whereas limb heaviness is often considered an association of muscle weakness. In order to address the hypothesis that the perception of limb heaviness may also be a problem of altered sensorimotor control, we investigated whether it was more closely related to post-stoke fatigue or muscle weakness. In 69 chronic stroke survivors we found that those with high perceived limb heaviness (31 subjects) also reported significantly higher levels of fatigue (4.8/7) than those with no perceived limb heaviness (38 subjects-fatigue score 2.68/7), but there was no difference in weakness between the two groups. This intriguing finding is discussed in relation to effort perception and sensory processing. The association between limb heaviness and post-stoke fatigue, and a dissociation from muscle weakness, gives rise to the hypothesis that limb heaviness maybe a centrally arising sensorimotor disorder.

Main text

Non-exercise related, chronic, perceptual fatigue is one of the most commonly reported symptoms after stroke[1] and can be defined as 'fatigue is a feeling arising from difficulty in initiation of or sustaining voluntary effort'. It can persist for years but little is known about its origins. Our recent work showed that those with high post-stroke fatigue exhibited low motor cortex excitability[2] and slowed movement times in the affected upper limb[3]. The behavioural deficits associated with fatigue were confined to the affected side. This unilateral rather than generalised slowing of movement supports the idea that the perceptual phenomenon of post-stroke fatigue results from focal abnormalities of sensorimotor processing and function. Here, we focus on another perceptual phenomenon commonly reported by stroke survivors - a sense of increased limb heaviness. In healthy subjects, peripheral muscle weakness leads to an overestimation of weight perception[4]. However, here we hypothesise that limb heaviness after stroke is a problem of central nervous system sensorimotor control, and so will be more closely linked to fatigue rather than peripheral muscle weakness. This would argue for both fatigue and sense of limb heaviness after stroke as perceptual manifestations of sensorimotor dysfunction.

Following written informed consent (ethics approval by Riverside Research Ethics Committee 12/LO/1474), sixty nine stroke survivors (60.36 years ± 12.4, 20 females and 56.81 months post stroke ± 63) with a first-time ischaemic or haemorrhagic stroke were recruited via Thames and South East Stroke Research Networks. Stroke survivors on anti-depressants or other centrally active drugs, high levels of motor and/or cognitive impairment as well as high Hospital Anxiety and Depression Scale score (>11) were excluded from the study. High motor impairment was defined as having less than 60% of the unaffected limb score in more than one of the following measures: a) Nine Hole Peg Test, b) Action Research Arm Test (ARAT) c) Grip strength. High cognitive impairment was defined as a score of more than 5 on Sustained Attention Index (SAI) and Symbol Digit Modalities Test. The tests were administered as previously described[2]. As previously used[2], a motor impairment score was obtained from a principal component analysis of the three motor scores. Fatigue was measured using the Fatigue Severity Scale-7 (FSS-7) and limb heaviness was measured by asking participants to either agree/strongly agree or disagree/strongly disagree with the statement 'My limbs can become very heavy'. Participants were instructed to answer the question based on how they felt in the last 2 weeks. A between group t-test was performed on FSS-7 scores and the motor impairment score. The two groups were those who agreed/strongly agreed with the statement and those who disagreed/strongly disagreed with the statement. Of the 69 participants 38 disagreed with the statement while the remaining 31 agreed with the statement (all patients reported heaviness with respect to the affected

limb). The average FSS-7 score of those who disagreed with the statement was 2.68 ± 1.54 (Mean ± SD) and those who agreed was 4.8 ± 1.53. There was a statistically significant difference between the FSS-7 scores of the two groups ($p < 0.001$), figure 1a. There was no significant difference between the motor impairment score of the two groups, figure 1b.

The main finding of this study is that those who report high fatigue also experience increased limb heaviness. Importantly, the average motor impairment score which included both muscle strength and dexterity was not different between groups. Although limb heaviness is a common complaint of stroke survivors, this is the first study to associate limb heaviness with self-reported fatigue in stroke survivors and dissociate limb heaviness from motor impairment.

Limb heaviness in stroke is commonly thought of as a manifestation of muscle weakness, an idea that emerges from experimental studies in healthy humans[4]. In healthy humans, perceived heaviness of an object placed on a limb is thought to arise from the re-afferent activity from the muscle spindles in the contracting muscle fibres. Following repeated contractions or administration of neuromuscular blocks, the peripheral muscle weakens and more muscle fibres contract when an object is placed on the limb when compared to the pre-weakened state. This results in increased re-afferent activity from the weakened muscles as more muscle fibres are recruited and the individual perceives an object placed on that limb as being heavier[5]. In the current study, although our patients were generally mild to moderately impaired, there was still a range of limb weakness and therefore of re-afferent activity during maintenance of arm position. However, limb weakness, and therefore presumably re-afferent activity, was not related to perceived heaviness. Therefore, one possible explanation for the relationship between fatigue and perception of limb heaviness is that central processing of normal re-afferent activity from the peripheral musculature may be altered in those with high post-stroke fatigue.

How might limb heaviness be related to effort perception? Effort perception is the ability to assess self-generated force and is thought to arise predominantly from central sensorimotor processing[6]. Effort perception and perceived heaviness can be thought of as two sides of the same coin as the former is an assessment of exerted force while the latter is an assessment of experienced force. In this context, it is plausible that the perception of limb heaviness can also be predominantly mediated by central processing and not by afferent information arising from peripheral musculature.

In summary, we show that limb heaviness, a common symptom after stroke (i) is not related to muscle weakness, (ii) is closely related to post-stroke fatigue

Post-stroke fatigue is commonly looked upon as a neuropsychiatric symptom[7], yet pharmacological interventions have proved futile[8,9] and there are no definitive treatments for fatigue[10]. The present work taken together with our previous work[2,3] suggests that changes within the sensorimotor system are more closely linked to development of non-exercise related post-stroke fatigue than previously thought. We also propose a novel mechanism of post-stroke fatigue which requires further testing.

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Legend

Figure 1: These box and whisker plots show the average fatigue scores (FSS-7 – y axis) of the two groups (1A) and the z-value of the Motor Impairment Score (1B) for the group that disagrees with the statement about limb heaviness and the group that agrees with the statement about limb heaviness.