Are people who do yoga any better at a motor imagery task than those who do not?

Sarah B Wallwork,[1] David S Butler,[1,2] Dianne J Wilson,[1] G Lorimer Moseley[1,3]

[1]The Sansom Institute for Health Research, University of South Australia, Adelaide, South Australia, Australia
[2]Neuro Orthopaedic Institute, Adelaide, South Australia, Australia
[3]Neuroscience Research Australia, Sydney, New South Wales, Australia

Correspondence to
Dr Lorimer Moseley, Body in Mind Research Group, Sansom Institute for Health Research, University of South Australia, GPO box 2471, Adelaide 5001 Australia; lorimer.moseley@gmail.com

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ABSTRACT

Background Yoga is a popular recreational activity in Western society and there is an abundance of literature suggesting that yoga may be beneficial for people with a chronic pain disorder. Despite consistently positive results in the literature, the mechanisms of effect are unclear. On the grounds that chronic pain is associated with disruptions of brain-grounded maps of the body, a possible mechanism of yoga is to refine these brain-grounded maps. A left/right body part judgement task is an established way of interrogating these brain-grounded maps of the body.

Objective To determine if people who do regular yoga practice perform better at a left/right judgement task than people who do not.

Methods Previously collected, cross-sectional data were used. Using a case–control design, participants who reported taking part in regular yoga were selected against age, gender, neck pain and arm pain-matched controls. Participants viewed 40 photographs of a model with their head turned to the left or right, and were asked to judge the direction of neck rotation. They then completed a left/right-hand judgement task.

Results Of the 1737 participants, 86 of them reported regularly taking part in yoga. From the remaining participants, 86 matched controls were randomly selected from all matched controls. There was no difference between Groups (yoga and no yoga) for either response time (p=0.109) or accuracy (p=0.964). There was a difference between Tasks; people were faster (p<0.001) and more accurate (p=0.001) at making left/right neck rotation judgements than they were at making left/right-hand judgements, regardless of group.

Conclusions People who do regular yoga perform no differently in a left/right judgement task than people who do not.

BACKGROUND

Yoga has been practised for thousands of years, and is a main-stream practice in some cultures. These days it is being practiced in Western cultures within the context of fitness and general health,[1 2] rehabilitation[3] and in the treatment of chronic pain.[4–7] Yoga has been associated with a reduction in pain in a wide variety of chronic pain disorders, including fibromyalgia,[8 9] chronic low back pain,[10–15] chronic neck pain,[16] osteoarthritis of the knee[17] or hand,[18] carpal tunnel syndrome,[19] delayed onset muscle soreness,[20] migraine,[21] headache,[22] rheumatoid arthritis,[23] labour pains[24] and in haemodialysis patients.[25] The quality of this literature is variable and has been published by a diverse range of international research groups (see Posadzki *et al*,[5] for systematic review of randomized controlled trials (RCTs) and Büssing *et al*[7] for meta-analysis). Overall the consensus seems to be promising for people with varying pain syndromes, and of the various yoga styles, Iyengar yoga seems to be the style of choice among the literature. Despite the vast literature with regard to yoga and pain and systematic review evidence of its positive effects,[5] there is no consensus on the mechanism(s) by which pain reduction is imparted.

One aspect of yoga that appears to be a possible mechanism for its effect relates to the purported impact of yoga on bodily awareness—the sense we have of our own body, and the space around us.[26] Yoga involves a series of integrative mind-body exercises that concentrate on stretching, balance and breathing, while incorporating aspects of meditation and relaxation and has been found to raise one's 'bodily awareness'[27–29] (see ref. 30 for a method of assessing bodily awareness—the Body Awareness Questionnaire). A fundamental tenet of yoga is that it heightens awareness of bodily sensations, awareness of movements and bodily alignment. One would predict then, that yoga should refine the brain-grounded maps of the body and the space around it—the so-called cortical proprioceptive representation.[26] This is very relevant to pain because distortions of the cortical representation of the body and the space around it are common in some pain states[26 31 32] and pain might be reduced by normalising this cortical representation.[33 34] Of course, this relationship might not be causal. Nonetheless, it seems feasible then that yoga assists in refining these cortical representations, which leads to pain reduction.

One challenge facing the verification of the key presumption, that yoga refines the cortical proprioceptive representation, is avoiding the confounds that occur when the entire posturomotor system is assessed. An established method of getting around this challenge is to use timed motor imagery tasks, a common version of which is the left/right body judgement tasks.[35–37]

Identifying a body part as belonging to the left or right side of the body requires matching the visual stimulus to stored mental representations that are held in the brain and then mentally manoeuvring one's own body part to match the posture shown in the picture in order to confirm the initial match[38]. Performance on these tasks matures prior to adolescence[39] and reflects the integrity of the cortical proprioceptive representation.[26 36] Decreased performance has been reported in a variety of clinical states (see table 1).

The present study aimed to use timed left/right judgement tasks to determine whether people who regularly do yoga are better at motor imagery than people who do not do yoga. We hypothesised that

Table 1 Decreased performance in left/right limb judgement tasks have been reported in a variety of clinical pain states

Author	Group	Findings
Schwoebel *et al*[40]	CRPS	Slower RTs for affected (painful) limb compared to unaffected limb
Schwoebel *et al*[41]	CRPS	Slower RTs for affected (painful) limb compared to unaffected limb in 180° orientation
Moseley[42]	CRPS	Slower RTs for affected limb compared to unaffected limb
Coslett[43]	Spatial neglect	Participants with left-sided neglect performed worse at identifying images of left hands, compared to controls
Nico *et al*[44]	Amputees	Amputees who lost their dominant hand made more mistakes and were significantly slower than controls
Bray and Moseley[35]	Back pain	Patients with bilateral back pain were less accurate at a left/right truck rotation task than those with unilateral back pain, who were in turn less accurate than controls
Bowering *et al* in press	Back pain	Participants with current back pain were less accurate than those without, and participants with a history of back pain were less accurate than those with no history
Leake *et al* unpublished thesis	Neck pain	Participants with chronic neck pain were less accurate than those with no neck pain
Stanton *et al*[45]	Painful knee osteoarthritis	Participants with knee pain were less accurate than healthy controls
Schmid and Coppieters[46]	Carpal tunnel syndrome	Participants with carpal tunnel were less accurate at identifying the affected hand compared to controls. Recognition of left/right neck rotation judgements were also less accurate in the carpal tunnel group
Fiorio *et al*[47]	Idiopathic cervical dystonia	Patients with idiopathic cervical dystonia took longer at both the left/right hand and foot judgement tasks, and also at a 'head block' task, where patients had to identify which eye was covered with a black patch at different head orientations
Fiorio *et al*[48]	Writer's cramp (focal hand dystonia)	Patients with writer's cramp were slower than controls at judging left/right hands, but not feet
Funk and Brugger[49]	Congenitally absent hands (hand amelia)	Unilaterally amelic participants were slower at identifying their missing hand, compared to their existing one. Bilateral amelic participants had longer reaction times to hands in unnatural positions compared with natural positions

CRPS, complex regional pain syndrome; RT, response time.

response time would be lower and accuracy higher in the yoga group than in an age, gender and pain-matched control group.

METHODS

Participants

We previously undertook a large, online cross-sectional investigation of left/right neck rotation judgements and left/right-hand judgements,[37] which involved 1737 male and female participants aged between 10 and 90 years, from 40 countries. Participants were recruited through social media strategies and through word of mouth. Participation required access to a web-connected computer. Instructions to participants included sitting upright in a chair and making themselves comfortable prior to undertaking the tasks which were to be presented on the monitor in front. Because of the online nature of the study, we were not able to maintain a controlled environmental set-up. Participants volunteered their time, and were able to withdraw from the study at any point.

Questionnaire

After informed consent was obtained, participants went on to complete a questionnaire regarding demographics, physical activity, pain and general health. With a view to asking the current question, we included an item in the questionnaire about participation in yoga for more than 30 min/week.

Images

For the motor imagery tasks, there were three versions, each involving a different batch of 40 images. The first batch involved left/right neck rotation judgements. Each image showed a portrait of a person, who was wearing a black T-shirt, with their head rotated to their left or right side, relative to their shoulders. There were equal numbers of left and right neck rotation, at 0°, 90°, 180° and 270° of image rotation. There were equal numbers of male and female images, and the photographs were taken from the front, back and side views. Participants performed the first task three times. The first performance was considered a practice run and the second task was used for analysis. The second batch used images that also contained contextual cues. Data from this task were also not analysed. The third task was a left/right hand judgement task.

Tasks

In the first two tasks, participants were required to respond to each image and identify whether the person in the image had their head rotated to their left or to their right. In the third task, they had to identify if the hand displayed was a left or a right hand. Responses were made using the 'a' key for a left-sided response and 'd' for a right-sided response. Each image was displayed until a response was made or 5 s had lapsed, then the next image would appear.

Data collection and ethical approval

Data were collected using Recognise (Neuro Orthopaedic Institute, Adelaide, Australia).The reliability of making left/right judgements has previously been established in people with and without pain and the internal validity of Recognise software has been demonstrated.[35] Ethical approval was granted by the institutional ethics committee.

Experimental design

We used a case–control comparison design. Participants who reported participating in yoga for at least 30 min a week were selected as cases. For each of those participants, one control participant was selected at random from all of the participants in the wider data set who matched exactly for age, gender and the presence of neck or arm pain (figure 1).

Data cleaning

The data were processed prior to analysis. Full data sets were removed if the questionnaire was not completed, or if all the tasks were not completed. Single responses were excluded if the

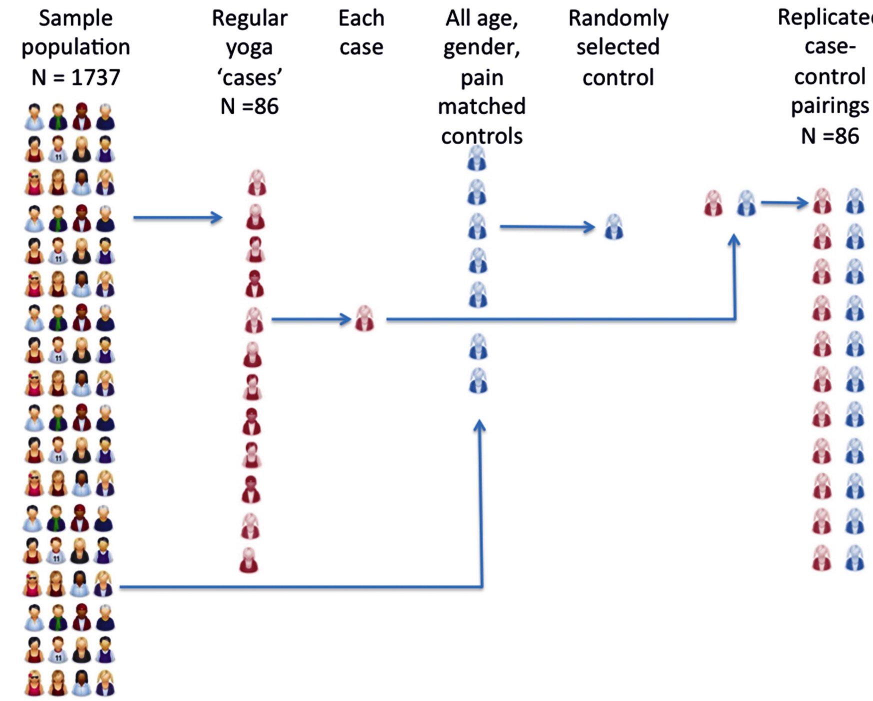

Figure 1 Flow diagram for case–control comparison design. Controls were randomly matched for age, gender and presence of neck and arm pain.

response was less than 500 ms, which was taken to be too short to reflect a true judgement response,[50] or if they timed out for eight or more (≥20%) images in a row, which was taken to reflect distraction from the task.

Statistical analyses

Data were analysed using SPSS V.19.0. Descriptive statistics were first analysed to identify the demographics of the two groups. Two repeated measures analyses of variances (ANOVAs) were conducted to identify if participants in the yoga group performed differently (response time and accuracy) at the two left/right judgement tasks. For each ANOVA, there was a within-subjects factor Task (two levels: hand judgements or neck rotation judgements) and a between-subjects factor Group (two levels: yoga or no yoga). Significance was set at $\alpha=0.05$.

RESULTS

Demographic data

Eighty-six participants reported taking part in at least 30 min of yoga each week. Therefore, there were two groups of 86 participants (figure 1).

For each group, age was normally distributed with a mean of 42±10 years. There were 79 women in each group. Participants were from 17 different countries. In each group, 13 participants reported neck pain, and 9 participants reported arm pain.

Yoga versus no yoga

For mean response times and accuracies see table 2.

Response time

Regular yoga was not associated with faster response times on either task—there was no main effect of Yoga ($F(1, 170)=2.59$, $p=0.109$). Regardless of whether or not they did yoga, participants were quicker at left/right neck rotation judgements than they were at left/right-hand judgements—there was a main effect of Task ($F(1, 170)=83.46$, $p<0.001$; figure 2). There was no Yoga×Task interaction ($p=0.909$).

Accuracy

The accuracy results mirrored the response time results: regular yoga was not associated with more accurate left/right judgements—there was no main effect of Yoga ($F(1, 170)=0.002$, $p=0.964$). Whether or not they did yoga, participants were more accurate at left/right neck rotation judgements than they were at left/right-hand judgements—there was a main effect of Task ($F(1, 170)=12.36$, $p=0.001$; figure 2). Again, there was no Yoga×Task interaction ($p=0.843$).

DISCUSSION

We hypothesised that response time would be shorter and accuracy higher in the yoga group than in an age, gender and pain-matched control group. The results do not support this hypothesis—response time and accuracy were no different between the groups and there was no Group×Task interaction.

Our results would not be predicted on the basis of the presumed relationship between bodily awareness and yoga participation.[27–29] Close interrogation of the available literature on perceptual and physiological effects of yoga puts our results into context. The literature currently suggests that yoga increases bodily awareness,[27–29] but our results would strongly suggest that this bodily awareness is limited to interoception, being the ability to consciously perceive bodily sensations, rather than proprioception, motor planning or spatial perception, which are

Table 2 Mean±SD for response times and accuracies for left/right neck rotation judgements and left/right-hand judgements for the yoga and no yoga groups

		Yoga	No yoga
Neck judgements	Response time (ms)	1722.07±507.77	1612.11±436.54
	Accuracy (%)	90.90±7.13	91.09±8.89
Hand judgements	Response time (ms)	2033.92±492.34	1931.88±510.49
	Accuracy (%)	88.65±9.09	88.57±9.90

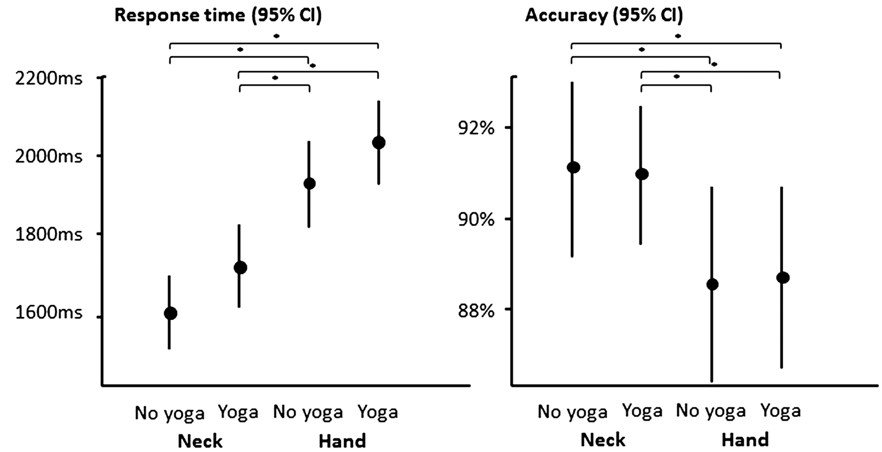

Figure 2 Mean (circles) and 95% CIs (error lines) for response time (left panel) and accuracy (right panel) for left right neck rotation judgements ('neck') and left/right hand judgements ('hand') for yoga practitioners ('yoga') and non-practitioners ('no yoga'). Asterisk (*) denotes differences at p<0.05.

more obviously targeted in motor imagery. We predicted that constant focus and attention onto various body parts during a sustained period of yoga practice would assist in building the integrity of cortical proprioceptive representation.[26] Our finding casts doubt over the idea that yoga helps chronic pain by improving the acuity of cortical proprioceptive maps, although our design does not permit strong conclusions in this area. There are other possible explanations for pain relief from yoga, for example downregulation of the hypothalamus-pituitary-adrenal axis, sympathetic or cardiorespiratory system mediated analgesia, improved strength and endurance, improved coordination, calmed and focused mind, positive emotions and optimism.[1 5–7] However, and importantly, good evidence for these mechanisms appears scant and as such, they remain speculative explanations. Notwithstanding, yoga is often seen as an important form of exercise and health maintenance[2] and it does have positive health benefits. A narrative review by Ross and Thomas[1] compared the impact of yoga and exercise on a variety of health outcomes and conditions. They found yoga interventions to be either equal or superior to exercise in most outcome measures, except for those related to physical fitness. Furthermore, a recent systematic review of RCTs looking to investigate the effectiveness of yoga as a treatment option for people in pain, found nine studies showing significantly greater pain relief in the yoga group when compared to various control interventions.[5] The 10th study in the review did not compare group differences in pain scores. Therefore, it seems that there is some potential for yoga to be effective for people in pain; in a variety of pain disorders.

Why were yoga practitioners no better than others at motor imagery? One possible contributor, and a clear contrast between yoga and the left/right judgement task, is the use of vision. Yoga involves performing mind-body exercises that would rely on several integrative sensory systems, including proprioceptive, tactile, vestibular and visual sensory systems that together compute where the body is in space. On the other hand, the left/right judgement task is predominantly a visuoproprioceptive task, whereby a visual image is integrated with proprioceptive and motor mechanisms. Yoga involves determining where the body is, whereas left/right judgements involve determining how one might get the body to a defined location. Notwithstanding these differences, that left/right judgements interrogate the cortical proprioceptive representation is well established[36 51] and that yoga practitioners performed no better than others certainly implies that they have no more precise or malleable cortical proprioceptive representations than non-practitioners have.

Our case-controlled design is a strength of the current study. However, it remains a cross-sectional comparison which means that we are unable to make confident statements about causality, or the lack thereof. We also used a 'normal' sample which included people in pain, although the majority were not in pain. Perhaps if we specifically investigated people in pain, in whom cortical proprioceptive representation is likely to be disturbed, we may then see a difference emerge according to yoga. Another possibility could be that people who reported taking part in yoga may have represented a sample biased towards people in pain. According to a 2002 National Survey in the USA, people with a certain medical condition (including musculoskeletal, mental health and asthma) were more likely to do yoga than were the general population,[2] although yoga users also reported a higher health status than non-users. So it seems possible that those who do yoga may be less precise in their cortical proprioceptive representations in the first place, which means that our null result masks a contrasting yoga-effect. These questions require alternative designs but clearly give impetus for further research.

That we found a difference in both response time and accuracy between left/right-hand judgements and left/right neck rotation judgements, regardless of yoga group, would be expected. On the grounds that response time reflects the time it would take to adopt the posture shown in the image[38] then we would predict small head movements to be quicker than sometimes complex hand movements. In addition, localising a target requires integration of positional data according to both an anatomical/proprioceptive frame of reference and a spatial frame of reference defined by the body midline.[26] If the left hand target is placed on the right side of the body midline, this introduces a conflict between the two frames of reference which is known to be associated with increased error rate and response times.[52] These issues probably do not occur with head rotations because the head/neck can be considered a single functional unit, unlike the hands, which are two collaborative but independent functional units. One consideration that we would predict to have the opposite effect to that observed here is that the hands are often positioned within the visual frame of reference—we most often use them in conjunction with vision. The neck, in contrast, is never visualised. One might predict then that this task relies on the integration of what a hand looks like with proprioceptive and motor processes, and therefore should be quicker for the hand than it is for the neck, which we did not find.

Although we employed a robust comparative design, there are limitations of our study that should be considered. First, we

What are the new findings

- People who do regular yoga are no better at motor imagery than people who do not.
- Left/right neck rotation judgements are easier than left/right-hand judgements.

How might it impact on clinical practice in the near future

- Our results suggest that yoga is not likely to improve motor imagery performance.
- The mechanism by which yoga helps people in pain appears unlikely to involve improvement of cortical body maps.

recognise the potential for unknown confounders that can be associated with a case-control study design, with the possibility of creating or masking effects. Second, we do not know what type of yoga our participants practiced, the frequency or duration of their sessions, how long they had been practicing yoga or for what reason they practiced yoga. We also had no control over each participant's set-up or whether or not they conformed with the recommended protocol. These limitations apply to all online studies and are very difficult to overcome, nonetheless they probably introduce variability in performance that must be remembered particularly when we find null results, such as this.

In summary, our results do not support the hypothesis that yoga practitioners perform better at left/right judgements than non-practitioners. This finding implies that yoga is not associated with a more precise or efficacious cortical proprioceptive representation.

Contributors SW, LM and DB were involved in conceptualisation; SW, LM and DB were involved in design; SW and DB were involved in data collection; SW and LM were involved in analysis; SW, LM, DB and DW were involved in interpretation and SW, LM, DB and DW were involved in writing the manuscript.

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Competing interests DB is Managing Director of Neuro Orthopaedic Institute Australasia, which sells Recognise, the software used for this study.

Ethics approval Divisional Human Research Ethics Committee at the University of South Australia.

Provenance and peer review Not commissioned; externally peer reviewed.

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