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Research article

Laterality of proprioception in the orofacial muscles and temporomandibular joint

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HIGHLIGHTS

- Closure movement proprioception is better at lips than jaw.
- Lip and jaw proprioceptive acuity are correlated on the right side but not on the left.
- Right side lips had higher discrimination acuity than left only for small objects.
- Findings consistent with use-based proprioception enhancement and matching for coordinated function.

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ABSTRACT

Laterality of function in the orofacial musculature suggests there may be side-to-side asymmetry of proprioceptive acuity in lip movement compared to the temporomandibular joint (TMJ). In the present work, 14 young adults were tested for acuity of lip and TMJ closure movements onto plugs varying from 5 to 8 mm without visual feedback. Testing was conducted on both left and right sides, using the same psychophysical task and stimuli. Results showed superior proprioceptive acuity at the lips, with no significant side effect. However, there was side-to-side asymmetry in the correlations between proprioceptive performance for the two anatomical structures, with performance on the right side strongly correlated but not on the left. This is consistent with the need for coordination between structures during chewing. When acuity at different points in the stimulus range was examined, the right side lips were better with small stimuli. Overall, results support enhanced use-specific proprioception.

1. Introduction

Laterality in the neurotypical, healthy face has been demonstrated with respect to two-point discrimination and range of motion during facial expression [6,11]. However, it is not currently known as to whether laterality is also apparent in the control of orofacial movement. The control of emotion, speech and proprioception has been linked to cerebral dominance. Specifically, in right-handers, speech is predominantly lateralized to the left hemisphere [10] and proprioception to the right hemisphere [20] and lower-limb proprioception is better on the non-dominant left side [25]. Thus there may be lateralization in the facial expression of emotion, as well as the conscious and subconscious control of the orofacial muscles. However, such lateral asymmetry has not been examined with respect to proprioceptive performance in facial structures. If "facedness" is present in orofacial structures, it could have clinical implications for whether or not visual feedback is the primary modality used for rehabilitation exercises, dependent on which side of the face or temporomandibular joint (TMJ) is affected. Additionally, laterality in facial and TMJ proprioception may support current theories of contralateral hemispheric control of non-preferred side proprioception [21].

Proprioception is a complex sensation involving the peripheral and central processing of information regarding position sense at rest (position sense) and during movement (kinaesthesia) that arises from peripheral mechanoreceptors and is centrally processed to match with a pre stored body map or schema of the body [5,17,19,22,23]. Proprioception is often researched in the context

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of injury rehabilitation and prevention in general musculoskeletal physiotherapy [36,38,44,47]. In relation to the face, knowledge of proprioception in a neurotypical population would aid in the prescription of exercises reliant on proprioceptive acuity, where these are used for people recovering from facial nerve paralysis, embouchure dystonia, facial injury or TMJ disorder. Deficits involving proprioception can be observed following various facial and TMJ injuries. For example, following facial nerve paralysis, there is a lack in synchronous movement at the mouth [13], and embouchure dystonia indicates a pathological overactivity of the lip sensory-motor system and involves involuntary contraction of the lips that is often seen in musicians [16,30]. Additionally, following Bell's palsy, altered sensation is reported without any clear sensory deficit [45]. It has been speculated that this disordered information is due to altered proprioception, as opposed to sensation as both travel along that same afferent pathways. In the TMJ, proprioception can be affected by TMJ disorder (TMD) [1], ankylosis [32], or hypermobility [9]. Interestingly, strong preference in chewing side has been linked to increased risk of TMD and to osseous changes in the TMJ in asymptomatic people [33,40,42].

Investigation into normal facial movement and sensation has shown that, independent of handedness, the left side of the face moves through more range of motion and is more involved in emotional expression than the right [12]. It has also been noted that two-point discrimination thresholds are lower on the left side of the face independent of gender [6], and that the threshold of discrimination for lateral movements of the mandible is lower on the left than on the right [51]. These findings would suggest a left side proprioceptive superiority. The focus of the current research was to investigate the motor control of the orofacial muscles and to determine whether there is a lateral asymmetry in proprioceptive acuity, in a manner similar to that observed in the upper and lower limbs [25,27] and eyes [7]. Recent research into the comparative proprioceptive acuity of the lips and TMJ when tested at the centre point has indicated greater acuity at the lips relative to the TMJ on the same psychophysical discrimination task despite a distinct lack of traditional proprioceptors (muscle spindles and Golgi tendon organs) in the facial musculature [15]. Importantly, the proprioceptive discrimination scores at the lips were found to correlate to the TMJ acuity scores, and it was hypothesised that this relationship could be explained by the extensive co-ordinated use of the lips and TMJ complex [15]. Improved proprioception due to extensive use has been documented across the body including in the ankle [4] and neck [24] and elite athletes have been found to have greater proprioceptive ability at sport relevant joints [26,29].

The unique usage of the orofacial muscles in facial expression; speech and mastication would imply complex cortical control as the orofacial muscles are subject to emotional control, volitional control and reflexive control. The cortical control areas for the motor control of emotional or volitional speech differ from those relating to emotional or volitional facial expression [8,31] thus it is unknown if cerebral dominance effects would be present in the orofacial muscles or if laterality could be related to extensive asymmetric use of the facial muscles.

Given extensive use in an asymmetric fashion, investigation for lateral asymmetry in proprioception seems warranted. The aim of this study is to determine whether or not laterality is present in the orofacial muscles in comparison to the TMJ when tested on the same psychophysical distance discrimination task. The asymmetry of movement at the mouth and previous proprioceptive work conducted at the midline lead to the hypothesis that the left side of the lips would have the greatest proprioceptive acuity, followed by the right lips and then the left and right TMJ. Laterality of proprioception has been identified in other research on the upper and lower limbs, with the non-dominant side found to have better proprioceptive acuity, and this has implications for rehabilitation exercises as it has been determined that dominant limb control relies more on visual feedback, and the non dominant side on proprioception [18,19,25,27]. If lateral asymmetry is seen in the movement discrimination ability of the lower face or TMJ, it could alter how these areas are rehabilitated, with or without visual feedback, given that typical rehabilitation programs for both areas involve the use of mirror biofeedback [3,14].

2. Materials and methods

2.1. Participants

Fourteen healthy volunteers between the ages of 18 and 65 (male 4 female 10; mean age 25.6 SD 3.9) were recruited from advertisements placed on notice boards at the University of Sydney Health Sciences campus. All potential participants were screened for facial, TMJ or dental injuries and disorders; facial nerve damage; significant lower facial deformities (e.g. cleft palate) and significant recent dental work. They were also screened for diagnosis of conditions that could significantly affect proprioception including: 1) neurological conditions (multiple sclerosis, Parkinson's disease, chronic fatigue syndrome) 2) recent heart failure 3) Type 1 or 2 diabetes 4) vestibular disturbances such as benign paroxysmal positional vertigo 5) rheumatoid arthritis. All volunteers had no chronic conditions and had no specific intensive motor control training involving the mouth or lips, such as from playing a musical instrument. The project was approved by the University of Sydney Ethics Committee (2014/641).

2.2. Design

Participants completed a repeated measures study involving two equivalent discrimination tasks, for both the lips and TMJ, tested on either side of the mouth.

2.3. Apparatus

A specific active movement extent discrimination apparatus (AMEDA) for the lips and TMJ was used. This apparatus was developed from dental research work [52] and was used to conduct the first test of lip versus TMJ proprioception, using a task at the midline of the mouth [15]. In the present study, discrimination ability of lip closure movements and TMJ closure movements on either side of the mouth were compared using this apparatus.

Four differently-sized cylindrical plastic plugs, with 1 mm diameter stepped differences, were used. The plug circumference was checked using Mitutoyo digital callipers (IP67 ABS Coolant Proof Calliper) to ensure a 1 mm step between each stimulus, as specified by the manufacturer. A 33.5 mm diameter plastic plug was used to create the standardised starting position for each trial at both the lips and TMJ (Fig. 1). The disposable plastic plugs and starting piece were attached to thin rods to enable ease of pre-use disinfection and presentation to the mouth.

To maximise the ecological validity of the test, participants were not restrained or blindfolded, although vision of the test piece was shielded [28]. The psychophysical method employed has been previously used in assessing proprioceptive ability in the upper and lower limbs, lower back, neck and TMJ, and met the validity criteria and number of trials needed to accurately estimate active movement discrimination ability [2,26].

2.4. Procedures

All the apparatus was sterilised using Milton solution and was stored in labelled zip-lock bags. Participants were screened for