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Original Article

The effects of cervical sustained natural apophyseal glides on neck range of movement and sympathetic nervous system activity

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A B S T R A C T

Background: Cervical sustained natural apophyseal glides (SNAGs) have been advocated for the treatment of spinal pain and range of movement restriction, however little is known about their mechanisms of action. Knowledge about their mechanisms should help understand the factors that influence the effectiveness of this technique.
Objectives: To study the immediate effects of SNAGs on neck range of movement (ROM) and sympathetic nervous system activity. To assess if a difference exists in the effects of ipsilateral and contralateral cervical SNAGs.
Design: Single blind, intervention randomised, within subject crossover.
Method: 30 asymptomatic subjects were recruited. Subjects were divided into an ipsilateral or contralateral SNAGs group. All subjects experienced a right C5 SNAGs, sham and control intervention on three separate days. Neck ROM, skin conduction (SC) and skin temperature (ST) in the right hand were measured.
Results: Right rotation ROM and SC increased following both SNAGs and sham interventions, with increases reaching statistical significance for ROM in the contralateral SNAGs group and for SC in the ipsilateral SNAGs group. No statistically significant differences were noted between ipsilateral or contralateral SNAGs and sham interventions. No significant changes in ST were noted.
Conclusion: C5 cervical right rotation SNAGs resulted in improved right rotation ROM and increased SC, however such effect was not greater than sham intervention. No effect was noted on ST. Further research is required to study the mechanism of action of SNAGs on symptomatic participants.

1. Introduction

Neck pain is an important public health problem. A recent health survey on nine thousand participants showed that 34% of participants had current neck or low back pain, and of these 97% had symptoms for greater than one month [1]. Neck pain alone accounts for 15% of all hospital-based Physiotherapy visits in the United Kingdom [2]. In a previous estimate in the Netherlands, neck pain accounted for 1% of the total healthcare expenditure [3], and more recently in the United States, the combined costs of neck and low back pain have been estimated to be as high as 1% of the gross domestic product [4]. Mobilisations are commonly used by osteopaths, physiotherapists, and chiropractors to treat neck pain [5].

Cervical sustained natural apophyseal glides (SNAGs) are a 'mobilisation with movement' technique in which a sustained accessory facet glide is applied together with active physiological movement [6]. The therapist may apply the glide over the spinous process (central SNAGs) or over the articular pillar on one side (unilateral SNAGs). SNAGs have been advocated for the treatment of neck pain and range of movement (ROM) restriction [6].

SNAGs have been shown to be effective for the treatment of neck pain [7,8], cervicogenic headaches [9], and cervicogenic dizziness [10]. However, predicting what patients may benefit from such intervention still remains a challenge. Whilst clinical prediction rules to identify respondents to cervical manipulative therapy may be helpful [11,12], our understanding as to why some patients

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respond positively to SNAGs and others do not has yet to be established. An understanding of the mechanisms of action of SNAGs should aid in determining the factors that influence the positive response of some patients and further inform the future study of predictive factors [13]. Possible mechanisms of action of SNAGs include centrally mediated hypoalgesia and sympathoexcitation, and restoration of positional faults and joint movement [14,15]. Only two studies have assessed the effect of SNAGs on sympathetic nervous system (SNS) activity and have reported contradictory findings. Moulson and Watson [16] studied the effects of a central C5/6 right rotation SNAGs and reported an increase in skin conduction (SC) in both upper limbs, which was only different from sham intervention after the application of the SNAGs but not during its application. They noted no effect on skin temperature (ST). Moutzouri, Perry [17] studied the effect of a central L4 flexion SNAGs and found no difference in SC in both lower limbs between SNAGs and sham interventions during or after the application of the SNAGs. We are not aware of any study which has assessed the effect of a unilateral SNAG on SNS activity.

Only one study has demonstrated an immediate increase in ROM in the cervical spine after a therapist applied SNAG [8]. These authors used a unilateral technique applied on the side contralateral to the direction of active movement (contralateral SNAGs). We are not aware of any study which has assessed the effect on ROM of a SNAGs applied on the side ipsilateral to the direction of movement (ipsilateral SNAGs).

The aim of this study was to assess the effects of a cervical rotation SNAGs on cervical range of movement (ROM) and SNS activity, and to establish if differences exist between the effects of an ipsilateral and a contralateral SNAGs.

2. Methodology

A single blind, intervention randomised, within subject cross-over design was used, which included control, sham and treatment interventions. Research ethics approval to conduct the study was obtained from the Oxford Brookes University Research Ethics Committee.

2.1. Recruitment

Based on a pooled standard deviation estimate in SC of 9.4% [18], a power of 80% and significance level set at 0.05, 30 asymptomatic subjects were recruited to detect a 10% difference [19]. Advertising posters placed within Oxford Brookes University were used to recruit a convenience sample of subjects to the study. Written informed consent was obtained after the procedure had been fully explained. Inclusion criteria were males and females from 18 to 65 years of age. Volunteers were excluded if they had symptoms in the neck and upper limb, previous experience of manual therapy, and history, symptoms, or medications which normally contraindicate manual therapy to the neck.

2.2. Skin conductance and skin temperature

SC and ST were measured using non-invasive probes (Biopac Systems Inc) placed on the palmar surfaces of the distal phalanx of the index, middle and ring fingers of the right hand. Because of the easy acquisition and reliability, SC and ST have been previously used for the measurement of SNS activity [20–24]. The Acknowledge® software (Biopac Systems Inc) was used to process data. SC was measured in microsiemens and skin temperature in degrees celcius.

2.3. Neck rotation range of movement

Cervical rotation ROM was measured using a Cervical Range of Motion (CROM) device [25]. Full neck rotation movements involved the subject actively rotating their head from a position of full right rotation to a position of full left rotation, and vice-versa. Measurements were repeated three times and the averaged value calculated to represent the participant's cervical rotation ROM.

2.4. Procedure

Participants were asked to attend the research laboratory for data collection on 3 different days. Participants were asked to avoid smoking, strenuous exercise, alcohol and caffeine for 2 h prior to the test [26]. Room temperature was controlled throughout the experiment.

Participants were divided and allocated systematically by order of participation to either an ipsilateral or a contralateral SNAGs group by one of the authors (ILA). All participants experienced a treatment intervention (either ipsilateral or contralateral SNAGs depending on group allocation), a sham intervention, and a control intervention. To avoid any order effect bias, the order in which the participants received the three interventions was randomised using computer generated random orders [27]. Participants were blind to their group allocation and intervention being tested.

Once neck rotation ROM was measured, participants were allowed to sit for 8 min for neurophysiological variables to stabilise [16]. Once stabilised, SC and ST were measured for 2 min before, during and 2 min after the intervention. After the post-intervention 2 min SC had been collected, neck rotation ROM was measured again.

2.5. Experimental interventions

All participants experienced 3 interventions: SNAGs, sham and control. The SNAG was applied as described by Mulligan [6]. One of the authors (NB), a Certified Mulligan Practitioner, applied a SNAG while the subject turned their head to the right 10 times. In the ipsilateral SNAGs, the SNAG was applied to the right articular pillar of C5, and in the contralateral SNAGs, the SNAG was applied to the left articular pillar of C5. In the sham intervention, the Physiotherapist applied manual contact to the articular pillar of C5 as with the SNAGs but without applying an accessory glide. In the control intervention, there was no physical contact between the subject and the Physiotherapist, and the subject remained seated without moving their head.

2.6. Data analysis

For the purpose of data analysis, SC and ST data was divided into pre-intervention, during intervention and post-intervention, and the mean for each period was calculated. For each intervention and subject the difference between pre-intervention vs during intervention, and pre-intervention vs post-intervention was calculated. Change in SC was expressed as a percentage difference from baseline, whereas change in ST was expressed in degrees celcius. The effect of the intervention on neck ROM was assessed by subtracting the pre-intervention ROM from the post-intervention ROM, and expressed in angular degrees.

All participants were included in the analysis in their original assigned group. Differences between experimental interventions were assessed using a repeated measures ANOVA with a post hoc Bonferroni correction. Significance level was set at $P < 0.05$ [19]. Because no significant differences were noted between SNAGs and sham interventions, no further statistical analysis was performed to

Table 1
Subjects' demographic characteristics.

	Ipsilateral SNAG group	Contralateral SNAG group
Age		
mean (SD)	28 [9]	30 [11]
range	19–44	18–48
Gender		
male	4 (27%)	7 (47%)
female	11 (73%)	8 (53%)

analyse differences between the ipsilateral and contralateral SNAGs.

3. Results

The subjects' demographic characteristics are shown in Table 1. Figs. 1 and 2 show neck rotation ROM before and after each intervention in the ipsilateral and contralateral SNAGs groups respectively.

Improvements in ROM were noted mostly in right rotation, where both the ipsilateral and contralateral SNAGs had a positive effect. In the contralateral SNAGs group, both sham and SNAGs interventions showed statistical significant improvements when compared to control (sham vs control $p = 0.007$; SNAGs vs control $p < 0.001$); no statistically significant differences were found between SNAGs and sham.

Figs. 3 and 4 show the percentage change in SC from baseline following each intervention in the ipsilateral and contralateral SNAGs groups respectively.

Both the ipsilateral and contralateral SNAGs caused an increase in SC, whereas in the control intervention a decrease in SC was observed. Sham intervention also caused an increase in SC, although of a lesser magnitude than SNAGs, especially in the contralateral SNAGs group. Differences were found to be statistically significant in the ipsilateral SNAGs group, between SNAGs and control (before vs during $p = 0.009$; before vs after $p = 0.018$), and between sham and control (before vs during $p = 0.006$; before vs after $p = 0.038$); differences were not found to be statistically significant between SNAGs and sham ($p > 0.05$).

Table 2 shows the change in skin temperature from baseline following each intervention in the ipsilateral and contralateral SNAGs groups. Minimal changes in skin temperature were recorded in all interventions and groups. No significant differences were found in either group.

4. Discussion

This study found increased ipsilateral neck ROM and SC following both SNAGs and sham interventions, with increases reaching statistical significance for ROM in the contralateral SNAGs group and for SC in the ipsilateral SNAGs group. No differences were noted between either ipsilateral or contralateral SNAGs and sham interventions. No changes were found in ST for any treatment intervention.

We found cervical SNAGs induced an increase in SC, however such increase was not different from that caused by sham intervention. This is in agreement with the findings of Moutzouri, Perry [17] who noted an increase in SC on the lower limbs both during a central SNAG on L4 and a sham intervention, with no significant differences detected between interventions. Increased SC was also observed by Moulson and Watson [16] in both sham and SNAGs interventions, but SNAGs only caused a significantly different change when compared to sham in the post-intervention period, with no differences detected during the intervention.

The findings of SNAGs and sham inverventions showing the same changes in SC might be explained by new information regarding the neuroanatomy in the brainstem. Wright and Vicenzino's [28] original model was based on work by Lovick [29], Lovick and Li [30] and Kuraishi, Harada [31] regarding the sympathetic nervous system and projections to and from the Periaqueductal gray (PAG). Since then new information regarding projections to the PAG from Bandler, Keay [32] and Bandler and Lovick [33], and more importantly from Lumb [34,35] suggest that the functional differentiation of fibre types peripherally, i.e. Aδ and C fibres, is continued within the central nervous system and particularly in the projections to the different areas of the PAG. For the dorso-lateral and lateral portions of the PAG their fibre projections are Aδ fibres, which are primarily located in the skin and outer tissues, whereas the C fibre input projects predominantly to

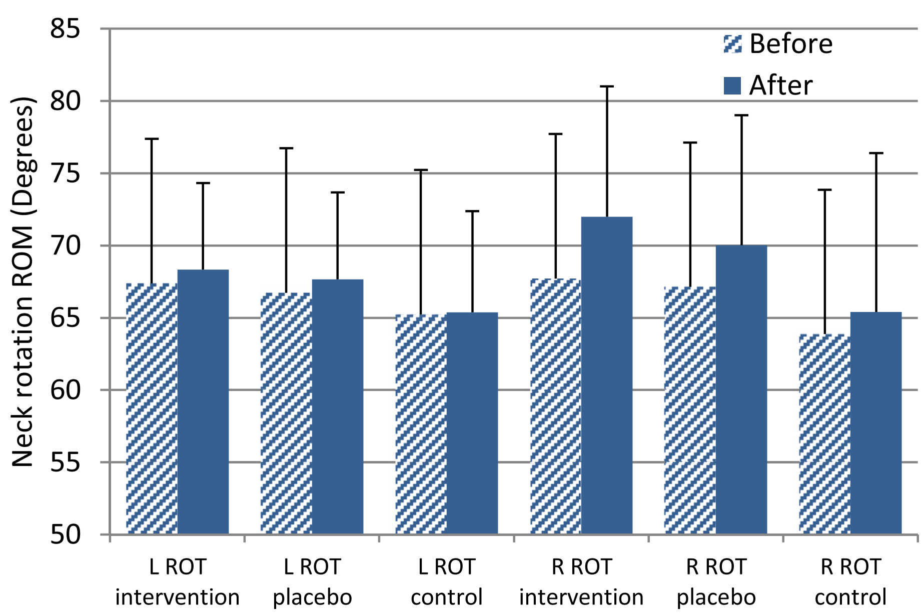

Fig. 1. Mean and SD neck rotation ROM before and after each intervention in the ipsilateral SNAG group.

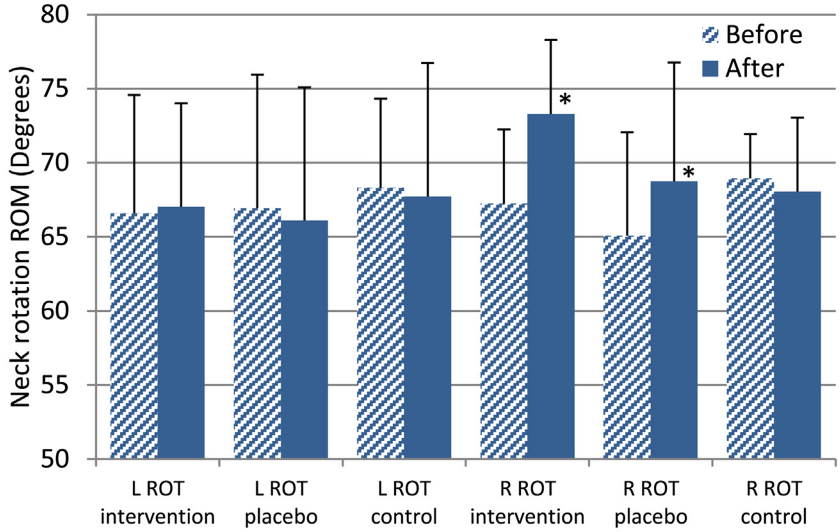

Fig. 2. Mean and SD neck rotation ROM before and after each intervention in the contralateral SNAG group. * represents statistical significant difference.

the ventrolateral PAG. It is the dorsal and dorsolateral PAG that is hypothesised to be involved in the mechanisms of non-opioid analgesia stimulated by manual therapy mobilisations, and this stimulus can be generated from the skin which would occur in both the mobilisation and sham interventions, accounting for some of the studies' results. Touch may have a key role in the sympathoexcitatory effect of manual therapies.

The effects of SNAGs on SC do not appear to be as significant as those reported during passive accessory mobilisation techniques [21,36,37]. SNAGs may not provide the oscillatory stimulus that has been noted is required for greatest change in SC [38]. Alternatively, the sympathoexcitatory effect may only be obtained to a great extent in symptomatic participants. It is of note that whilst a change in SC over sham has been reported in all studies assessing the effect of mobilisations on symptomatic participants [21,36,37], findings have not been that consistent when the studies involved asymptomatic participants [16,18,39,40]. Changes in SC only reached statistical significance with the ipsilateral SNAGs, which may suggest that the application of an ipsilateral glide may have a greater sympathoexcitatory effect.

ST was found not to be responsive to any intervention in either group. This is in agreement with the findings of Moulson and Watson [16] and suggest that cervical SNAGs have no effect on ST. The findings of other studies that have used accessory mobilisations have been varied. Chiu and Wright [38]_ENREF_4 _ENREF_27and La Touche, Paris-Alemany [21] reported no effect of mobilisations on ST. On the contrary, Sterling, Jull [36] and Vicenzino, Collins [37] reported significant changes in ST following cervical mobilisations, although these were of a small magnitude (1–3%). Cervical SNAGs appear to cause no change in ST, and even when present in other forms of manual therapy, the response of ST appears to be of a lesser magnitude and less regular than SC. SC is

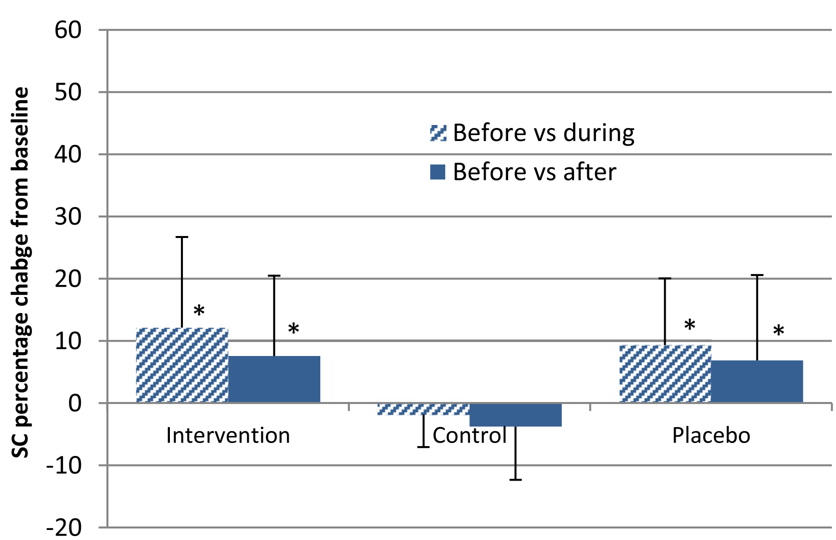

Fig. 3. Percentage change (mean and SD) in resting SC in all interventions in the ipsilateral SNAG group. * represents statistical significant difference.

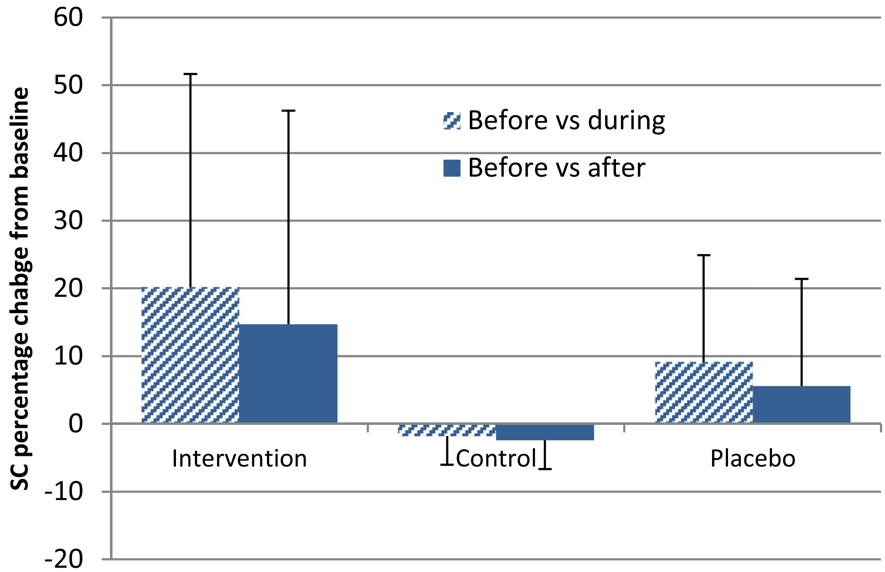

Fig. 4. Percentage change (mean and SD) in resting SC in all interventions in the contralateral SNAG group.

dependent upon sweat gland activity; since the sweat gland is exclusively innervated by the SNS, skin conduction is widely acknowledged as a marker of SNS activity [22,41]. Whilst ST has been used as to assess SNS activity [21,36], ST may be affected by factors other than the SNS, and ST may not accurately represent SNS activity [42]. This may explain the differences in the behaviour of ST and SC observed in the current and previous studies.

SNAGs have been advocated for pain reduction and ROM restoration [43], this study provides further evidence of the positive effect of SNAGs on ROM. Cervical ROM only improved in the direction of the technique which supports the specificity of this technique. Sham and SNAGs produced a similar effect. It is possible that ROM restoration in patients may be secondary to the repeated rotation movements performed during the application of the technique, a component which was present in both SNAGs and sham in our study. On the other hand, participant expectation has also been found to be associated with the therapeutic effect of an intervention [44]. Blinding of the participants may have facilitated a similar expectation of effectiveness from both the intervention and sham, resulting in an equal improvement in ROM.

4.1. Limitations and future research

ST and SC were only recorded in the right side of the participants; it is unknown if the changes observed occurred bilaterally or only on the same side of the SNAGs. Changes in SC are attributed to the central nervous system, although studies collecting bilateral data on SC are required to confirm this. This study set out to investigate the effects of SNAGs on ROM and SNS function in asymptomatic participants. However, it is not known if a similar response would have been seen in symptomatic participants. Participants were not assessed for the presence of restricted ROM and it is possible that larger effects may have been seen if participants had demonstrated movement restriction.

Future research should investigate the effects of SNAGs on ROM and SNS function in symptomatic participants.

Table 2
Change (mean and SD) in temperature (degrees celcius) in all interventions in the ipsilateral and contralateral groups.

	Ipsilateral SNAG group			Contralateral SNAG group		
	Intervention	Sham	Control	Intervention	Sham	Control
Before vs during	−0.003 (0.007)	−0.008 (0.012)	−0.002 (0.013)	−0.007 (0.014)	−0.008 (0.011)	−0.004 (0.012)
Before vs after	0.001 (0.008)	−0.001 (0.006)	−0.002 (0.006)	−0.004 (0.015)	−0.009 (0.015)	−0.006 (0.022)

Negative sign indicates a decrease.

5. Conclusion

C5 cervical right rotation SNAGs resulted in improved right rotation ROM and increased SC. However such effect was not greater than sham intervention. No effect was noted on ST.

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Ethical statement

The study design and procedures were approved by Oxford Brookes University Research Ethics Committee.

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