Immediate and short-term effects of mulligan concept positional sustained natural apophyseal glides on an athletic young-adult population classified with mechanical neck pain: an exploratory investigation

Dawn P. Andrews^a , Kari B. Odland-Wolf^b, James May^c, Russell Baker^c, Alan Nasypany^c and Eric M. Dinkins^d

^aFit For Work, Houston, TX, USA; ^bDepartment of Athletics, University of South Carolina, Columbia, SC, USA; ^cCollege of Education, Movement Sciences, University of Idaho, Moscow, ID, USA; ^dSelect Medical, Castle Rock, CO, USA

ABSTRACT

Objectives: Mechanical neck pain (MNP) is common in the athletic population. While symptoms may present at the cervical spine for patients complaining of MNP, thoracic spinal alignment or dysfunction may influence cervical positioning and overall cervical function. Clinicians often employ cervical high-velocity low-amplitude (HVLA) thrust manipulations to treat MNP, albeit with a small level of inherent risk. Mulligan Concept positional sustained natural apophyseal glides (SNAGs) directed at the cervicothoracic region are emerging to treat patients with cervical pain and dysfunction, as evidence supporting an interdependent relationship between the thoracic and cervical spine grows. The purpose of this a priori study was to evaluate outcome measures of patients classified with MNP treated with the Mulligan Concept Positional SNAGs.

Methods: Ten consecutive young-adult patients, ages ranging from 15 to 18 years (mean = 16.5 ± 1.78), classified with MNP were treated utilizing Mulligan Concept Positional SNAGs. The Numeric Rating Scale (NRS), Patient-Specific Functional Scale (PSFS), Neck Disability Index (NDI), Disablement in the Physically Active (DPAS), and Fear-Avoidance Based Questionnaire-Physical Activity (FABQPA) were collected for inclusion criteria and to identify patient-reported pain and dysfunction.

Results: Patients reported decreases in pain on the NRS [5.4 to .16, $p = .001$], increases in function on the PSFS [5.2 to 10, $p = .001$], and increases in cervical range of motion (CROM) [ext $p = .003$, flex $p = .009$, left rot $p = .001$, right rot $p = .002$] immediately post-treatment and between treatments.

Discussion: Positional SNAGs directed at the cervicothoracic region may address a variety of patient reported symptoms for MNP, and the number of treatment sessions needed for symptom resolution may be closer to a single session rather than multiple treatments.

Level of Evidence: 4.

KEYWORDS

Mechanical neck pain;
cervicothoracic junction;
mobilization with movement

Introduction

Mechanical neck pain (MNP) is a musculoskeletal disorder commonly affecting the weekend warrior and high-level athlete alike. Patient-athletes report spinal pain and dysfunction at an equal or greater rate than the general population, with estimates up to 15% of all sports-related injuries [1]. Surveillance efforts in the athletic population traditionally focused on traumatic cervical spine injuries [2,3] rather than pathology categorized as MNP. Mechanical neck pain is defined as: nonspecific pain in the area of the cervicothoracic junction without an identifiable pathoanatomical cause, and most frequently requires that the pain be exacerbated by motion [4–7]. The subset of the athletic population hampered by MNP has been approximated at 36% of all neck pain [8], and poses unique treatment challenges to

the sports medicine clinician, as limited evidence supporting effective interventions is available [9]. Although cervical spine manipulation, also referred to as high-velocity low-amplitude (HVLA) thrust, is often employed to treat patients with MNP, disagreement persists over the efficacy of the application [10–27].

Compared to the cervical and lumbar regions, the thoracic spine is largely neglected in the research literature. Thoracic spine dysfunction is often overlooked due to complicated anatomy, biomechanics, function, proximity to vital organs, and articulation with ribs which can result in false diagnoses and insufficient treatment [28]. Manual therapy intervention strategies such as HVLA thrusts are frequently based on theoretical models of mechanical dysfunction and elucidating symptoms which do not present at the thoracic spine [29]. Researchers and clinicians alike theorize that thoracic spine joint mobility

disturbances may be an underlying contributor to musculoskeletal disorders in the cervical spine, providing the rationale to include HVLA thrust manipulation and/or non-thrust mobilization to the thoracic spine to treat patients with MNP [30].

Childs et al. [4,31] and Cleland et al. [32] investigated the utilization of thoracic HVLA thrusts on patients presenting with MNP to determine combinations of variables obtained from self-report measures, patient history, and clinical examinations that may lead to long-term benefits received from thoracic manual therapy. A set of Clinical prediction rules (CPRs) resulted from the investigations, allowing further investigation of alternative manual therapy interventions for treating MNP including the Mulligan Concept (MC) Mobilization with Movement (MWM).

The MC MWM treatment approach which combines passive accessory glides (i.e. mobilizations) with active movement is indicated to increase joint range of motion (ROM), decrease pain, and enhance muscle function when treating musculoskeletal pain and/or dysfunction [33–39]. The rapid pain-relieving mechanical effect is primarily based on the presence of articular positional faults and realignment through MWMs to correct said faults [39,40]. Similarly, the MC sustained natural apophyseal glide (SNAG) technique has been reported to create sympatho-excitatory effects [41] and increases in ROM [42] when treating musculoskeletal dysfunction at the spine. The use of thoracic SNAGs is recommended as a suitable manual therapy technique to treat patients classified with MNP, as the neurophysiological effects of SNAGs such as immediate hypoalgesia and an increase in pressure-pain thresholds have been highlighted in the research [36,40,43,44].

Currently, no attempts have been made to examine the effect of positional SNAGs directed at the cervicothoracic region on pain and disability in patients classified with MNP. The purpose of this *a priori* study was to evaluate disease- and patient-oriented outcome measures of patients classified with MNP treated with the MC positional SNAGs.

Materials and methods

Between April 2016 and September 2016 10 consecutive patients who presented to the athletic training clinic with complaints of MNP were evaluated in the same manner to determine eligibility for inclusion in this multi-site study. Investigators followed the ethical guidelines set forth by the institutional review boards and followed protocol for human subject investigation. Parental consent and athlete assent were obtained prior to data collection. Participant confidentiality was protected according to the United States' Health Insurance Portability and Accountability Act.

Subjects

Patients, 7 males and 3 females with a mean age ($\pm$ SD) of 16.5 ($\pm$ 1.78) years, represented a variety of

secondary and collegiate sports and reported neck pain of a non-traumatic musculoskeletal nature within the previous 30 days without seeking treatment for the current presentation. Inclusion was based on a presentation of symptoms consistent with the classification of MNP and congruity of two or more of the classification-based inclusion criteria established by Cleland et al. [32]; absence of upper-extremity symptoms distal to shoulder, onset of symptoms < 30 days, looking up does not aggravate symptoms, Fear-Avoidance Beliefs Questionnaire-Physically Active (FABQPA) score < 12, diminished upper thoracic spine kyphosis, and cervical extension ROM < 30° plus specified scores on the Numeric Rating Scale (NRS), Neck Disability Index (NDI), and Patient Specific Functional Scale (PSFS). Utilization of the Cleland et al. CPR was intended as a means for inclusion criteria only and not for the purposes of treatment efficacy or outcome analysis.

Patients were excluded from the study if they presented with: medical 'red flags' indicating non-musculoskeletal etiology (e.g. suspected fracture), positive Spurling's or Cervical Distraction Test, history of whiplash within 6 weeks of examination, diagnosis of cervical spinal stenosis, or evidence of CNS involvement (e.g. decreased neurological response distal to shoulder).

Outcome measures

Investigators began the examination by administering the NRS [45–50], and PSFS [51], outcomes measures as well as collecting patient-reported history relating to duration, mode of onset, nature of symptoms, and aggravating/relieving factors. To evaluate the effect of treatment for MNP, clinicians utilized patient-reported outcome measures to assess perceived levels of pain (NRS) and functional disability (PSFS) as well as disease-oriented outcomes (i.e. active cervical ROM) [52,53] to measure cervical function and global efficacy of treatment [54–56]. Investigators recorded cervical flexion and extension ROM utilizing the Inclinator application for their respective smart phones, and recorded cervical rotation utilizing a standard goniometer. Investigators utilized minimal clinically important differences (MCIDs) and minimal detectable change (MDC) to interpret patient-reported outcomes measures including benefits derived from treatment, impact upon the patient, and implications for clinical management of the condition. Outcome measurements were collected at the initial-evaluation, following the 3rd treatment, and at a two-week follow-up visit.

Study design

After obtaining consent and establishing inclusion, each patient assessment to determine the vertebral level of treatment began by the clinician first assessing spinous process tenderness at C2–T4 vertebral levels, followed

Figure 1. Hand placement for positional SNAG.

by the patient performing cervical flexion, extension, and rotation while the clinician palpated for vertebral hypomobility [57,58]. The matched level of spinous process tenderness and hypomobile segment was deemed the initial treatment level. The clinician completed a single sub-therapeutic dose of the positional SNAG at the established treatment level (assessed hypomobile segments) and corresponding side of the most painful cervical ROM self-selected by the patient. The clinician started by placing thumb on the higher ipsilateral side (ROM restriction) segments and opposite thumb on the lower contralateral side of the spinous process providing a translational direction of the glide (Figure 1) while the patient actively performed previously reported restricted ROM. In the event the patient did not report a pain-free, immediate, and long-lasting (PILL) effect to the sub-therapeutic treatment the clinician adjusted (e.g. re-directed angle and/or intensity) the positional SNAG to earn the necessary PILL effect. Inability to elicit a pain-free response at the originally assessed level caused the clinician to move to the next vertebral level directly adjacent to the originally assessed segment and provide another single sub-therapeutic positional SNAG. A maximum of three consecutive vertebral levels was assessed, and the treatment level was determined as the level in which the sub-therapeutic dosage of the positional SNAG combined with the patient-reported PILL effect.

The treating athletic trainers have an average of 12 years of clinical experience, and both completed 3 Mulligan Concept Upper Extremity courses including practical training in the use of cervical and thoracic positional SNAGs. To ensure inter-rater consistency all examination, outcome assessments, and treatment techniques were standardized (i.e. body position, goniometric landmarks for both standard goniometer and inclinometer, hand placement), video recorded, and shared between clinicians and reviewed by a third-party clinician (20 years of clinical experience). Also, video recordings were reviewed by a Mulligan Concept Teachers Association

Figure 2. Overpressure for Positional SNAG. Source: Author.

(MCTA) certified practitioner to establish intervention face validity and consistency between the investigating clinicians. The same procedures were utilized with each patient encounter.

Treatment intervention

Treatment began at the vertebral level determined during the patient evaluation and sub-therapeutic positional SNAG assessment (C5 = 3, C6 = 3, C7 = 1, T1 = 2, T4 = 1). The investigator provided verbal instructions for the patient to move into the previously restricted motion and provide over-pressure at the end-ROM while the investigator maintained the transverse glide for a set of 10 repetitions (Figure 2). After the patient clearly understood treatment parameters and the importance of a pain-free treatment, each patient was treated therapeutically. The clinician applied the positional SNAG at the previously identified level for a total treatment of 3 sets of 10 repetitions with one-minute rest between sets. After completing treatment, all patients resumed normal sport activity without restriction, were instructed not to consume anti-inflammatory or pain medication, or to perform any home exercise program (HEP) between treatment sessions.

Each patient was treated three times with at least 24–72 h separating each treatment. During each treatment session, both pre- and post-treatment outcome measures for NRS, and PSFS were collected while cervical range of motion (CROM) was recorded before each treatment session only. All patients returned after 24 h and two weeks following the third treatment to assess both short-term and long-term effects on pain and function.

Data analysis

Data were analyzed using SPSS version 22.0 (SPSS Inc., Chicago, IL, USA). One-way repeated measures analysis of variance (RM-ANOVA) tests were conducted to evaluate the effect of MC SNAGs on the NRS, PSFS, and CROM across time. Mean differences from the initial-visit scores and 95% confidence intervals (CIs) were calculated for the NRS, PSFS, and CROM for post-3rd treatment and two-week follow-up. Significant changes were further analyzed with Bonferroni *post hoc* testing. Prior to data analysis, normality of distribution was assessed with the alpha level set at $p < .05$. Effect size differences were computed with Partial Eta squared (η_p^2). A small effect size is $\eta_p^2 = 0.02$; medium effect size is $\eta_p^2 = 0.13$; large effect size is $\eta_p^2 = 0.26$ [28].

Results

Numeric rating scale

Application of MC SNAGs resulted in statistically significant improvements in pain (NRS) over time (Tables 1 and 2). The mean changes in NRS scores from initial-visit to post-1st treatment, from initial-visit to post-3rd treatment, and from initial-visit to two-week follow-up were significant. Further analysis revealed 8/10 patients achieved significant clinical and statistical improvement in pain (4-point reduction) exceeding the MCID²⁹ post-1st treatment, and all patients (10/10) maintained their clinical gains at the two-week follow-up examination. Overall effect size for pain was 0.91 (Table 2).

Patient-specific functional scale

Application of MC SNAGs also produced statistically significant improvements in function (PSFS) over time (Tables 1 and 2). The mean changes in PSFS scores from initial-visit to post-1st treatment, from initial-visit to post-3rd treatment, and from initial-visit to two-week follow-up were significant. The mean change in PSFS scores from initial exam to two-week follow-up exam exceeded the MDC value on the PSFS [30]. Of greater clinical relevance for the MDC values, 6/10 of patients reported a PSFS score exceeding the MDC value (3.5-point improvement) after the 1st treatment. At the two-week follow-up, 10/10 of patients reported a score of 10. Overall effect size for function was 0.92 (Table 2).

Cervical ROM

The mean values and 95% CI of within-subject comparison and the interaction effect between time are listed in Tables 3 and 4 respectively.

Clinical prediction rule

Secondary to investigating the effects of positional SNAGs on MNP, we examined whether the 6 predictor variables identified by Cleland et al. [32] correspond to current patient-reported symptoms and outcomes. The results of this study illustrate that the Cleland et al. [32] CPR did not need to be fully satisfied to achieve a positive outcome. Cleland recommends for a successful treatment utilizing HVLA thrusts to occur a minimum

Table 1. NRS and PSFS Mean Values from Initial Evaluation to 2-Week Follow-up

	Initial evaluation	Post 1st treatment	Pre 2nd treatment	Post 2nd treatment	Pre 3rd treatment	Post 3rd treatment	2 week follow-up
NRS	5.4	1 ^a	1.7	0.6	0.7	0.1	.16
PSFS	5.2	7.7 ^b	8.5	9.0	8.95	9.8	10

^aMCID achieved after first treatment; MCID = 2-point change for NRS;

^bMDC achieved after first treatment; MDC = 2-point change for PSFS.

Table 2. Numeric rating scale (NRS) and patient specific functional scale (PSFS) statistical and clinical significance for pain from baseline to 2-week follow-up.

	Initial evaluation	2-week follow-up	Total mean change	MCID/MDC	p-value	Partial eta squared
NRS	5.40	.16	5.07	2	<.001*	0.91
PSFS	5.20	10.00	4.80	2	<.001*	0.92

NRS = Numeric Pain Rating Scale; MCID = Minimal Clinically Important Difference; PSFS = Patient Specific Functional Scale; MDC = Minimal Detectable Change.

Table 3. Cervical range of motion means values and 95%CI for interaction effect between time from baseline to 2-week follow-up.

	Initial evaluation to post 1st treatment mean [95%CI]	Initial evaluation to post 3rd treatment mean [95%CI]	Initial evaluation to 2-week follow-up mean [95%CI]
CROM-EXT	13.44 [33.31–6.43]*	27.05 [46.86–7.23]**	28.68 [50.47–6.88]**
CROM-FLEX	12.60 [30.50–5.30]*	23.12 [44.14–2.09]*	16.07 [41.89–8.49]*
CROM-ROT L	8.65 [19.20–1.90]*	17.22 [30.21–4.22]**	26.55 [39.72–13.39]***
CROM-ROT R	12.50 [26.26–1.26]***	19.82 [30.91–8.72]***	22.15 [35.69–8.60]***

* $p < .05$; ** $p < .01$; *** $p < .001$.

Table 4. Cervical range of motion within-subjects effects from baseline to 2-week follow-up.

	Initial evaluation	Post 1st treatment	Post 3rd treatment	2-Week follow-up	Total mean change	MDC	p-value	Partial eta squared
CROM-EXT	58.0°	71.4°	85.0°	86.71°	28.6°	7.0°	.003*	0.64
CROM-FLEX	50.0°	62.2°	73.1°	66.74°	16.7°	9.6°	.009*	0.46
CROM-ROT L	58.4°	67.1°	75.6°	85.00°	26.5°	6.7°	.001*	0.87
CROM-ROT R	67.3°	79.8°	87.1°	89.45°	22.1°	7.6°	.002*	0.70

MDC = Minimal Detectable Change.

of 4 predictive variables (93% post-test probability of success) should be present, however the subjects in this study reported a mean of 3 predictor variables and reported treatment success.

Discussion

In this exploratory multi-site study two novice practitioners of MC utilized positional SNAGs at the cervicothoracic region to treat patients complaining of pain and disability at the cervical spine initially classified with MNP. All participants in this study reported both clinically and statistically significant improvement across outcome measures of pain, function, and CROM.

Clinical experience and preliminary evidence suggest that thoracic spine thrust manipulation may be useful in the management of patients with neck pain [59]. The biomechanical link between the cervical spine and the thoracic spine suggest that disturbances in joint mobility in the thoracic spine may serve as an underlying contributor to the development of neck disorders. In addition, it has been demonstrated that a significant association exists between decreased mobility of the thoracic spine and the presence of patient-reported complaints associated with neck pain [60]. Regional interdependence is defined as, 'seemingly unrelated dysfunction in a separate region of the body that may contribute to the patient's chief complaint' [61]. Utilizing the RI model and treating the thoracic spine utilizing interventions such as high-velocity low-amplitude (HVLA) thrusts and sustained natural apophyseal glides (SNAGs) in clinical practice creates an expanded approach for treating MNP beyond the traditional local techniques.

The evidence provided in this study significantly outperformed evidence previously reported [62–68] on the effects of treating MNP utilizing thoracic HVLA manipulations after the 1st treatment. Those previous investigations reported effect sizes ranging from .17 to .54 (small to moderate) for pain scores on the NRS whereas a .91 effect size (large) was achieved during this study investigation. Direct comparison of pain scores in the previous studies is difficult due to the time intervals in which post-1st treatment results were reported. The time intervals ranged from 24-h, 48-h, and 1-week time intervals [62–68] whereas pain scores during this study were collected immediately post-1st treatment session. In addition, direct comparison of pain scores is equally difficult as patients in the aforementioned studies;

ranged in age from 18–70 years, reported experiencing subacute and chronic MNP symptoms to those in our study who experienced more acute symptoms, and were not involved in interscholastic or intercollegiate athletics.

Important to daily activity and sport specific activities, all participants reported clinically and statistically significant improvements with function (PSFS) at both post-1st treatment and at two-week follow-up. Investigators of previous studies did not report measures of function making comparison difficult; however, a .92 (large) effect size and improvement in patient-reported function in this study exceeded the established MDC [51] for the PSFS immediately post-1st treatment, at post-3rd treatment, and the improvement was maintained at 2-week follow-up.

After the first treatment, CROM improvements met previously established MDCs of 7.0° for extension, 9.6° for flexion, 7.6° for right rotation, and 6.7° for left rotation [69,70]. El-Sodany et al. [67] reported a 'significant difference' in range of motion in flexion, extension and rotation after 6 weeks of cervical SNAGs combined with exercise therapy or HVLA manipulations combined with exercise therapy, and Izquierdo-Perez et al. [68] applied a total of 4 cervical SNAG treatment sessions over 2 weeks, reporting increases in flexion by 8.3°, extension by 13.3°, and rotation (combined) by 12.6° after the initial treatment. In this study, overall CROM measurement increases (12.6° for flexion, 13.4° for extension, and 10.5° for combined rotation) as well as effect size were equal to the results reported by Izquierdo-Perez et al. [68] within the first treatment session. However, our overall CROM measurement increases (23.1° for flexion, 27° for extension, and 18.5° for combined rotation) as well as effect size outgained those of Izquierdo-Perez et al. [68] post-3rd treatment (11.5° for flexion, 20° for extension, and 11.6° for combined rotation).

Isolation of the patient-reported direction of CROM restriction for cervical flexion revealed a trend toward a greater increase in ROM and effect size over time. Hypothesized reasons for the reported large clinical gains for those with restricted cervical flexion include: (1) the mobilization with movement towards the restricted area utilizing positional SNAGs technique, (2) possible increase in one direction of motion leading to a carry-over effect to the other CROM through restoration of normal biomechanics within the cervicothoracic region, (3) and a 'ceiling effect' to the increased ROM within the overall cervical flexion ROM group, as those patients who did

not demonstrate significant losses in the overall cervical flexion ROM group under-valued clinical improvement demonstrated in cervical flexion restriction group. Although it was not the primary purpose of the study, further investigation into the cervical flexion group revealed a pattern of improvement beyond the MDC for the respective motion. While the expected normal value for cervical flexion is 80°, the mean initial range of motion deficit from 'norm' was 47.5° compared to post-treatment #3 of 7.84° for a mean improvement of 39.66° ($t(4) = 8.15, p < .001$, two-tailed). The reasons for the substantial decrease in initial range of motion in the cervical flexion group are unclear. Further investigation would be necessary to determine whether patients may experience subacute somatic dysfunction prior to treatment resultant to dysfunction that the body tolerates without triggering the neuromuscular reflexive cascade and causing restriction that become recognizable to the patient.

A potential predictor for the success of the SNAG intervention in MNP may be the duration of symptoms. Flynn et al. [30] identified 'duration of current episode' as the strongest predictor for identifying patients with low back pain who are likely to experience a rapid and dramatic response to lumbar HVLA thrusts, and Cleland et al. [59] also demonstrated that a shorter duration of symptoms was predictive for identifying patients with cervical neck pain who would respond to thoracic HVLA thrusts. During this study, intervention for the majority ($n = 7$) of MNP occurred within 24 h of symptom onset, and in some cases ($n = 3$) immediately after sustaining non-traumatic cervical trauma. The clinical and statistical improvement reported after the first treatment session may indicate that intervention within 24 h of onset of symptoms utilizing the positional SNAG technique directed at the cervicothoracic region may result in greater reduction of symptoms, as SNAGs reduce soft tissue inflammation, induce relaxation and improve function before restricted movements, tissue irritability, and compensatory patterns set in [71]. This may be especially meaningful for clinicians who provide acute assessment and care on patients by providing immediate changes that are long lasting in patient outcomes opposed to the previously reported timeline of 4–6 weeks of treatment intervention if access to treatment is delayed [62–68].

Limitations of present study

The primary limitation of this study is the lack of comparison groups; one group receiving HVLA manipulations, one a group receiving positional SNAGs, and one a control group to treat MNP. Much of the current information and data regarding SNAGs are in the form of randomized control studies utilizing unilateral cervical SNAGs, and no research has been completed to determine the effects of positional SNAGs on patients complaining of MNP. Further examination in the form of controlled trials is

necessary to determine whether different SNAG application procedures (e.g. increased or decreased load and treatment length) produces similar patient outcomes [68,72].

Potential bias of practitioners is also a limitation of this study. In situations of MC positional SNAGs, it is difficult if not impossible to prevent bias associated with blinding, as each clinician knows which treatment they are providing. To reduce the risk of potential 'practitioner' bias, the investigators remained blind to each other's activities regarding the performing of treatments throughout the study data collection period.

In this study, a CPR proposed by Cleland et al. [32] was utilized as a guide to identify patients complaining of MNP who may benefit from positional SNAGs directed at the cervicothoracic region. While this study utilized the Cleland et al. [32] CPR, two limitations must be discussed: (1) The CPR was originally intended as a means of predicting variables to identify patients with neck pain likely to benefit from HVLA manipulation not SNAGs; and (2) The CPR has not been validated in subsequent studies [73]. Numerous clinical guidelines are present in the literature regarding spinal pain, yet a lack of consensus exists regarding their effectiveness due to wide variability of spinal therapy interventions. Further research is needed to identify a valid CPR for the treatment of MNP using the positional SNAG technique [20,74,75]. Utilizing the Cleland et al. [32] CPR may also have limited the population size, however utilizing a multi-center approach improves the likelihood of finding subjects matching the inclusion criteria [76]. While the sample size in our study was small, we feel it was sufficient to produce statistically significant and clinically meaningful outcomes keeping in mind a larger sample size is preferable to narrow CIs and be more representative of the population. In addition, we chose to be conservative with our statistical analyses and used a Bonferroni correction. Despite this approach, our results demonstrated significant differences within-subjects on outcome measures at all follow-up points.

Conclusion

This study was conducted to serve as a preliminary step in the investigation of the effects of positional SNAGs in patients classified with MNP in the athletic population. While further research is necessary, the positive results reported in this study provide support for MC positional SNAGs as an alternative treatment option for patients presenting with MNP, regardless of a patient's status on the CPR. Although a small sample size, our results support and reinforce that positional SNAGs have positive effects on MNP. Those receiving positional SNAGs exhibited substantial reductions in pain after 1 treatment and meaningful improvements in function after 3 treatments that were both statistically and clinically significant.

Disclosure statement

No potential conflict of interest was reported by the authors.

Notes on contributors

Dawn P. Andrews is currently an injury prevention specialist with Fit For Work in Houston, TX. Andrews's research interests are focused on manual therapy interventions, specifically Mulligan Concept Sustained Natural Apophyseal Glides (SNAGs) for the treatment of mechanical neck pain in the industrial population.

Kari B. Odland-Wolf is a clinical instructor in the Undergraduate and Graduate Athletic Training Programs at the University of South Carolina. Odland-Wolf's research interests are focused on manual therapy interventions, specifically Mulligan Concept Sustained Natural Apophyseal Glides (SNAGs) for the treatment of mechanical neck pain and unresolved chronic low back pain in the athletic population.

James May is the clinical education coordinator for the Doctorate Athletic Training program at the University of Idaho. His research interests are focused on action research in athletic training including patient outcomes and manual therapy techniques for treating musculoskeletal pathologies.

Russell Baker is the master's of Science in Athletic Training Program Director and clinical assistant professor at the University of Idaho. Baker's research interests are focused on instrument development and validation, utilizing manual therapy interventions for musculoskeletal pathology and musculoskeletal injury and examination.

Alan Nasypany is the Program for Athletic Training at the University of Idaho.

Eric M. Dinkins is a physical therapist for Select Medical in Castle Rock, CO. He is a member of the Mulligan Concept Teacher's Association.

ORCID

Dawn P. Andrews <http://orcid.org/0000-0002-9074-6812>
 Alan Nasypany <http://orcid.org/0000-0001-6308-3278>

References

- [1] Dreisinger TE, Nelson B. Management of back pain in athletes. *Sports Med.* 1996;21(4):313–320.
- [2] Durall C. Therapeutic exercise for athletes with nonspecific neck pain: a current concepts review. *Sports Health.* 2012;4(4):293–301.
- [3] Zmurko MG, Tannouty TY, Tannouty CA, et al. Cervical sprains, disc herniations, minor fractures, and other cervical injuries in the athlete. *Clin Sports Med.* 2003;22(3):513–521.
- [4] Childs MJD, Fritz JM, Piva SR, et al. Proposal of a classification system for patients with neck pain. *J Orthop Sports Phys Ther.* 2004;34(11):686–700.
- [5] Cross KM, Kuenze C, Grindstaff T, et al. Thoracic spine thrust manipulation improves pain, range of motion, and self-reported function in patients with mechanical neck pain: a systematic review. *J Orthop Sports Phys Ther.* 2011;41(9):633–642.
- [6] Bogduk N. Clinical and radiological anatomy of the lumbar spine and sacrum. 4th ed. Elsevier: Philadelphia (PA); 1984.
- [7] Bronfort G. Efficacy of manual therapies of the spine: a critical appraisal and review of the literature. Thesis Publishers Amsterdam, Amsterdam; 2001.
- [8] Stump JL, Redwood D. The use and role of sport chiropractors in the National Football League: A short report. *J Manipulative Physiol Ther.* 2002;25(3):A2–A5.
- [9] Weinstein SM. Assessment and rehabilitation of the athlete with a “stinger”: a model for the management of non-catastrophic athletic cervical spine injury. *Clin Sports Med.* 1998;17(1):127–135.
- [10] Gross A, Miller JD'Sylva, J, et al. Manipulation or mobilization for neck pain: a cochrane review. *Manual Ther.* 1996;15:315–333.
- [11] Bitterli J, Graf R, Robert F, et al. Zur Objektivierung der manualtherapeutischen Beeinflussbarkeit des spondylogenen Kopfschmerzes [Objective criteria for the evaluation of chiropractic treatment of spondylotic headache]. *Nervenarzt.* 1977;48:259–262.
- [12] Bronfort G, Haas M, Evans RL, et al. Efficacy of spinal manipulation and mobilization for low back pain and neck pain: a systematic review and best evidence synthesis. *Spine J.* 2004;4(3):335–356.
- [13] Bronfort G, Nelson B, Aker P et al. A randomized controlled clinical trial of rehabilitative exercise and spinal manipulation for chronic neck pain. Effects on neck pain and disability, functional health status, biomechanical neck dysfunction, and somato-visceral symptoms. Proceedings of the 1996 International Conference on Spinal Manipulation; Oct 18–19; Bournemouth; 1996. p. 67–70.
- [14] Bronfort G, Aker PD, Evans R et al. A randomized controlled clinical trial of rehabilitative exercise and chiropractic spinal manipulation for chronic neck pain. Proceedings of the Scientific Symposium, 1997 World Chiropractic Congress; June 6–8; Tokyo, Japan; 1997. p. 62–64.
- [15] Bronfort G, Evans R, Nelson B et al. A randomized controlled clinical trial of spinal manipulation and exercise for chronic neck pain: a report on neck performance outcomes after 11 weeks and long-term effects on patient-rated outcomes. Proceedings of the 1998 International Conference of Spinal Manipulation Foundation for Chiropractic Education and Research; Vancouver, Canada; 1998. p. 62–68.
- [16] Bronfort G, Evans R, Nelson B, et al. A randomized clinical trial of exercise and spinal manipulation for patients with chronic neck pain. *Spine.* 2001;26(7):788–797.
- [17] Cassidy JD, Lopes AA, Yong-Hing K. The immediate effect of manipulation versus mobilization on pain and range of motion in the cervical spine: a randomized controlled trial. *J Manipulative Physiol Ther.* 1992;15(9):570–575.
- [18] David J, Modi S, Aluko AA, et al. Chronic neck pain: a comparison of acupuncture treatment and physiotherapy. *Br J Rheumatol.* 1998;37(10):1118–1122.
- [19] Koes BW. Efficacy of manual therapy and physiotherapy for back and neck complaints. Maastricht, Netherlands: Maastricht University; 1992.
- [20] Koes BW, Bouter LM, Essers AH, et al. A randomized clinical trial of manual therapy and physiotherapy for persistent back and neck complaints: subgroup analysis and relationship between outcome measures. *J Manipulative Physiol Ther.* 1993;16(4):211–219.
- [21] Koes BW, Bouter LM, Knipshild PG, et al. The effectiveness of manual therapy, physiotherapy and continued treatment by the general practitioner for chronic nonspecific back and neck complaints: design of a randomized clinical trial. *J Manipulative Physiol Ther.* 1991;14(9):498–502.

- [22] Koes BW, Bouter LM, Van Mameren H, et al. Randomised clinical trial of manipulative therapy and physiotherapy for persistent back and neck complaints: results of one year follow up. *BMJ*. 1992;304(6827):601–605.
- [23] Koes BW, Bouter LM, van Mameren H, et al. The effectiveness of manual therapy, physiotherapy, and treatment by the general practitioner for nonspecific back and neck complaints. *Spine*. 1992;17(1):28–35.
- [24] Nilsson N, Christensen HW, Hartvigsen J. The effect of spinal manipulation in the treatment of cervicogenic headache. *J Manipulative Physiol Ther*. 1997;20(5):326–330.
- [25] Parkin-Smith GF, Penter CS. The efficacy of spinal manipulative therapy in the treatment of mechanical neck pain. Proceedings of the Scientific Symposium, 1997 World Chiropractic Congress; June 2–8; Tokyo, Japan. Toronto: World Federation of Chiropractic; 1997.
- [26] Sloop PR, Smith DS, Goldenberg EVA, et al. Manipulation for chronic neck pain. A double-blind controlled study. *Spine*. 1982;7(6):532–535.
- [27] Vernon HT, Aker P, Burns S, et al. Pressure pain threshold evaluation of the effect of spinal manipulation in the treatment of chronic neck pain: a pilot study. *J Manipulative Physiol Ther*. 1990;13(1):13–16.
- [28] Edmondston SJ, Singer KP. Thoracic spine: anatomical and biomechanical considerations for manual therapy. *Manual Ther*. 1997;2(3):132–143.
- [29] Ashmen K, Swanik CB, Lephart S. Strength and flexibility characteristics of athlete with chronic low-back pain. *J Sports Rehabil*. 1996;5:275–286.
- [30] Flynn T, Fritz J, Whitman J, et al. A clinical prediction rule for classifying patients with low back pain who demonstrate short-term improvement with spinal manipulation. *Spine*. 2002;27(24):2835–2843.
- [31] Childs JD, Fritz JM, Flynn TW, et al. A clinical prediction rule to identify patients with low back pain most likely to benefit from spinal manipulation: a validation study. *Ann Intern Med*. 2004;141(12):920–928.
- [32] Cleland JA, Childs JD, Fritz JM, et al. Development of a clinical prediction rule for guiding treatment of a subgroup of patients with neck pain: use of thoracic spine manipulation, exercise, and patient education. *Phys Ther*. 2007;87(1):9–23.
- [33] Collins N, Teys P, Vicenzino B. The initial effects of a Mulligan's mobilization with movement technique on dorsiflexion and pain in subacute ankle sprains. *Manual Ther*. 2004;9(2):77–82.
- [34] DeSantis L, Hasson SM. Use of mobilization with movement in the treatment of a patient with subacromial impingement: a case report. *J Manual Manipulative Ther*. 2006;14(2):77–87.
- [35] Exelby L. Peripheral mobilizations with movement. *Manual Ther*. 1996;1(3):118–126.
- [36] Mulligan BR. Manual therapy: "NAGS", "SNAGS", "MWMS" etc. Wellington: Plane View Services; 2004.
- [37] Paungmali A, O'Leary S, Souvlis T, et al. Hypoalgesic and sympathoexcitatory effects of mobilization with movement for lateral epicondylalgia. *Phys Ther*. 2003;83(4):374–383.
- [38] Teys P, Bisset L, Vicenzino B. The initial effects of a Mulligan's mobilization with movement technique on range of movement and pressure pain threshold in pain-limited shoulders. *Manual Ther*. 2008;13(1):37–42.
- [39] Vicenzino B, Collins D, Benson H, et al. An investigation of the interrelationship between manipulative therapy-induced hypoalgesia and sympathoexcitation. *J Manipulative Physiol Ther*. 2007;21:448–453.
- [40] Hearn A, Rivett DA. Cervical SNAGs: a biomechanical analysis. *Manual Ther*. 2002;7(2):71–79.
- [41] Moulson A, Watson T. A preliminary investigation into the relationship between cervical snags and sympathetic nervous system activity in the upper limbs of an asymptomatic population. *Manual Ther*. 2006;11(3):214–224.
- [42] McNair PJ, Portero P, Chiquet C, et al. Acute neck pain: cervical spine range of motion and position sense prior to and after joint mobilization. *Manual Ther*. 2007;12(4):390–394.
- [43] Fernández-de-las-Peñas C, Cuadrado ML, Arendt-Nielsen L, et al. Myofascial trigger points and sensitization: an updated pain model for tension-type headache. *Cephalalgia*. 2007;27(5):383–393.
- [44] Fernandez-de-Las-Penas C, Alonso-Blanco C, Miangolarra JC. Myofascial trigger points in subjects presenting with mechanical neck pain: a blinded, controlled study. *Manual Ther*. 2007;12(1):29–33.
- [45] Downie W, Leatham P, Rhind V, et al. Studies with pain rating scales. *Ann Rheum Dis*. 1978;37:378–381.
- [46] Jensen MP, Karloy P, Braver S. The measurement of clinical pain intensity: a comparison of six methods. *Pain*. 1986;27:117–126.
- [47] Jensen MP, Turner JA, Romano JM. What is the maximum number of levels needed in pain intensity measurement? *Pain*. 1994;58(3):387–392.
- [48] Jensen MP, Miller L, Fisher LD. Assessment of pain during medical procedures: a comparison of three scales. *Clin J Pain*. 1998;14:343–349.
- [49] Katz JN, Melzack R. Measurement of pain. *Surg Clin North Am*. 1999;79:231–252.
- [50] Price D, Bush F, Long S, et al. A comparison of pain measurement characteristics of mechanical visual analog and simple numerical rating scales. *Pain*. 1994;56:217–226.
- [51] Novak CB, Anastakis DJ, Beaton DE, et al. Validity of the patient specific functional scale in patients following upper extremity nerve injury. *Hand*. 2013;8(2):132–138.
- [52] Daponte P, De Vito L, Picariello F, et al. State of the art and future developments of measurement applications on smartphones. *Measurement*. 2013;46(9):3291–3307.
- [53] Franko OI, Tirrell TF. Smartphone app use among medical providers in ACGME training programs. *J Med Syst*. 2012;36(5):3135–3139.
- [54] Hurst H, Bolton J. Assessing the clinical significance of change scores recorded on subjective outcome measures. *J Manipulative Physiol Ther*. 2004;27(1):26–35.
- [55] Jaeschke R, Singer J, Guyatt GH. Measurement of health status. Ascertaining the minimal clinically important difference. *Control Clin Trials*. 1989;10:407–415.
- [56] Kamper SJ, Maher CG, Mackay G. Global rating of change scales: a review of strengths and weaknesses and considerations for design. *J Manual Manipulative Ther*. 2009;17(3):163–170.
- [57] Cleland JA, Childs JD, Fritz JM, et al. Interrater reliability of the history and physical examination in patients with mechanical neck pain. *Arch Phys Med Rehabil*. 2006;87(10):1388–1395.
- [58] Sandmark H, Nisell R. Validity of five common manual neck pain provoking tests. *Scand J Rehabil Med*. 1995;27(3):131–136.
- [59] Cleland JA, Childs JD, McRae M, et al. Immediate effects of thoracic manipulation in patients with neck pain: a randomized clinical trial. *Manual Ther*. 2005;10:127–135.
- [60] Norlander S, Nordgren B. Clinical symptoms related to musculoskeletal neck shoulder pain and mobility in the

- cervicothoracic spine. *Scand J Rehabil Med.* 1998;30:243–251.
- [61] Sueki D, Cleland J, Wainner RA. Regional interdependence model of musculoskeletal dysfunction: research, mechanisms, and clinical implications. *J Manual Manipulative Ther.* 2013;21(2):90–102.
- [62] Saavedra-Hernández M, Castro-Sánchez AM, Arroyo-Morales M, et al. Short-term effects of kinesio taping versus cervical thrust manipulation in patients with mechanical neck pain: a randomized clinical trial. *J Orthop Sports Phys Ther.* 2012;42(8):724–730.
- [63] Dunning JR, Cleland JA, Waldrop MA, et al. Upper cervical and upper thoracic thrust manipulation versus nonthrust mobilization in patients with mechanical neck pain: a multicenter randomized clinical trial. *J Orthop Sports Phys Ther.* 2012;42(1):5–18.
- [64] Puente-dura EJ, Landers MR, Cleland JA, et al. Thoracic spine thrust manipulation versus cervical spine thrust manipulation in patients with acute neck pain: a randomized clinical trial. *J Orthop Sports Phys Ther.* 2011;41(4):208–220.
- [65] Muller R, Giles LG. Long-term follow-up of a randomized clinical trial assessing the efficacy of medication, acupuncture, and spinal manipulation for chronic mechanical spinal pain syndromes. *J Manipulative Physiol Ther.* 2005;28(1):3–11.
- [66] Cleland JA, Glynn P, Whitman JM, et al. Short-term effects of thrust versus nonthrust mobilization/manipulation directed at the thoracic spine in patients with neck pain: a randomized clinical trial. *Phys Ther.* 2007;87(4):431–440.
- [67] El-Sodany AM, Alayat MSM, Zafer AMI. Sustained natural apophyseal glides mobilization versus manipulation in the treatment of cervical spine disorders: a randomized control trial. *Int J Adv Res.* 2014;2(6):274–280.
- [68] Izquierdo Pérez H, Alonso Perez JL, Gil Martinez A, et al. Is one better than another? A randomized clinical trial of manual therapy for patients with chronic neck pain. *Manual Ther.* 2014;19(3):215–221.
- [69] Cross KM, Kuenze C, Grindstaff T, et al. Thoracic spine thrust manipulation improves pain, range of motion, and self-reported function in patients with mechanical neck pain: a systematic review. *J Orthop Sports Phys Ther.* 2011;41(9):633–642.
- [70] Fletcher JP, Bandy WD. Intrarater reliability of CROM measurement of cervical spine active range of motion in persons with and without neck pain. *J Orthop Sports Phys Ther.* 2008;38(10):640–645.
- [71] Horton SJ. Acute locked thoracic spine: treatment with a modified SNAG. *Manual Ther.* 2002;7(2):103–107.
- [72] Begg C, Cho M, Eastwood S, et al. Improving the quality of reporting of randomized controlled trials. The CONSORT statement. *JAMA.* 1996;276:637–639.
- [73] McClune T, Burton AK, Waddell G. Whiplash associated disorders: a review of the literature to guide patient information and advice. *Emergency Med J.* 2002;19(6):499–506.
- [74] Cai C, Lim KC. A clinical prediction rule for classifying patients with low back pain who demonstrate short-term improvement with mechanical lumbar traction. *Eur Spine J.* 2009;18:554–561.
- [75] Dechartres A, Boutron I, Trinquart L, et al. Single-center trials show larger treatment effects than multicenter trials: evidence from a meta-epidemiologic study. *Ann Intern Med.* 2011;155(1):39–51.
- [76] Rubinstein SM, van Eekelen R, Oosterhuis T, et al. The risk of bias and sample size of trials of spinal manipulative therapy for low back and neck pain: analysis and recommendations. *J Manipulative Physiol Ther.* 2014;37(8):523–541.