ORIGINAL ARTICLE

Movement discrimination after intra-articular local anaesthetic of the ankle joint

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Background: The effect on clinical safety of dampening articular mechanoreceptor feedback at the ankle is unknown. Injection of the ankle joint for pain control may result in such dampening. Athletes receiving intra-articular local anaesthetic may therefore be at increased risk of sustaining ankle injuries, which are a common reason for missed sporting participation.

Objective: To determine the effect of intra-articular local anaesthetic on movement discrimination at the ankle joint.

Design: Prospective, randomised, double-blinded, placebo-controlled, cross-over trial.

Setting: Australian Institute of Sport Medical Centre, Canberra, Australia.

Patients: Twenty two healthy subjects (44 ankles) aged 18–26 were recruited for the three visits of the study.

Interventions: Subjects were tested for their initial movement discrimination scores using the active movement extent discrimination apparatus (AMEDA). They then received ultrasound-guided intra-articular injections of local anaesthetic (2% lignocaine hydrochloride) or normal saline, on two separate later occasions, before further AMEDA assessment.

Main outcome measures: Change in movement discrimination scores after intra-articular injection of local anaesthetic or saline.

Results: Movement discrimination scores were not significantly different from control ankles after injection of either local anaesthetic or saline into the ankle joint.

Conclusions: The intra-articular injection of neither 2 ml lignocaine nor an equivalent amount of normal saline resulted in significant effects on movement discrimination at the ankle joint. These results suggest that injections of local anaesthetic into the ankle joint are unlikely to significantly affect proprioception and thereby increase injury risk.

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Ligamentous ankle injuries are among the most common sports trauma, accounting for 10–30% of all sports injuries.¹ These injuries involve the weaker lateral ligaments in up to 85% of cases, with 3–5% isolated to the stronger medial deltoid ligament complex.² Injuries are most often sustained playing basketball, the football codes, netball or in the aesthetic sports.³

Assessment of lower limb motor function has been performed using an active movement extent discrimination apparatus (AMEDA) that measures movement discrimination ability on the basis of obtained proprioception, thereby giving a score that reflects ability to sense small differences in the range of ankle movement in weight-bearing stance, closely replicating functional movement conditions. A subject who can differentiate small differences in the extent of ankle range of motion may be better able to position their foot and ankle to avoid injury and maximise performance.⁴ Scores obtained with the AMEDA have been shown to be sensitive to the presence of textured insoles in footwear during discrimination of ankle inversion movements.⁵ Accordingly, the technique should also be sensitive to any performance-detrimental effects of intra-articular local anaesthetic, should any occur.

Postural control depends on information provided by visual cues, vestibular function, and proprioceptive input derived from mechanoreceptors located primarily in muscle and skin,⁶ but also in tendon, ligament and joint capsule.⁷ Extensive research has been carried out focusing on the pathophysiological aetiology of ankle injuries, in particular the role of proprioceptive deficits and postural sway as a cause of, or predisposer to, ankle injury and/or a hindrance to rehabilitation.^{8–16} Reimann *et al*¹⁷ state “understanding the role of articular receptors in postural control may help to explain some of (the) controversial

results, as well as provide a more objective basis to many commonly used clinical rehabilitation procedures.” Freeman and Wyke¹⁸ produced direct evidence in support of the importance of articular receptors in sensorimotor control over (knee) joint stability. Since then, the few studies that have focused solely on the function of ankle joint receptors in postural control have looked at anaesthetising the lateral ligament complex, with varied results but generally showing no deleterious effects on postural control.^{17–20} Furthermore, these studies have predominantly tested single-leg stance. Some researchers have questioned the presence of a challenge upon the postural control system using the static characteristics of single-leg balance.²¹ Other studies have also failed to demonstrate deficits in proprioception after anaesthesia of the lateral ankle ligament, and have suggested a dominant input from “more important” musculotendinous receptors.^{22–23}

Although proprioceptive deficits after intra-articular injections of local anaesthetic to the knee and metacarpophalangeal joints have not been demonstrated,^{24–25} no studies to date have looked at the consequences of isolating the intra-articular mechanoreceptors in the ankle. This study aims to determine the role of ankle joint mechanoreceptors in proprioceptive input, under conditions of ankle joint perturbation in upright, weight-bearing, non-restrained subjects. Performing discrete, self-initiated and self-paced active movements resulting in a functional interaction with the environment is seen as more closely replicating functional movement conditions than the continuous adjustment movements typically made to maintain upright stance in balance tasks.

Use of local anaesthetic in professional football codes is widespread, where anaesthetic is traditionally added to

cortisone preparations for injection of joints or soft tissues in an attempt to expedite resolution of inflammatory states. Athletes may also be injected with local anaesthetic alone just before sporting participation, with the aim of allowing pain-free participation while not retarding the final stages of injury rehabilitation.

Other pathologies about the ankle that are also often treated by injection, such as lateral ligament complex or tibiotalar impingement syndromes, are in such proximity to the ankle joint capsule that unguided injections—as is done in most cases clinically—must be associated with a “risk” of injecting into the articular space. Although Barrack *et al*²⁴ have shown that no proprioceptive deficits follow intra-articular injections at the knee (although not implying that the practice does not carry inherent risks), the present study was undertaken to investigate whether intra-articular local anaesthesia of the ankle predisposes recipients to altered ankle movement control and therefore to potentially heightened risk of ankle injury.

METHODS

Subjects

Twenty two subjects (16 female/6 male) aged 18–26 were recruited from health science faculties of local tertiary education institutions in Canberra and staff of the Australian Institute of Sport. Subjects were recruited by advertisements on faculty notice boards and email advertising at the Australian Institute of Sport. Prospective subjects were interviewed, and physical examination was performed to determine study eligibility. All were physically active (defined as recreationally active for 30 min at least twice a week) but did not participate if they met any of the following exclusion criteria.

- Allergy to lignocaine hydrochloride
- Ankle sprain in past 3 months
- Use of ankle brace or strapping in daily activities and/or recreation
- Known arthritis/joint disease of lower back, hip, knee, ankle
- Significant head injury in the past month
- Labyrinthine or vestibular disease
- Current or recent (past 2 weeks) ear or sinus infection
- Peripheral neuropathy (including diabetes/multiple sclerosis)
- Ingestion of medication with known potential deleterious effects on balance, coordination or alertness
- Needle phobia
- Pregnancy

All subjects signed an informed consent form and were provided with a “participant information sheet”. The project

Figure 1 Ultrasound-guided intra-articular injection of ankle joint. Informed consent was obtained for publication of this figure.

was approved by the human ethics committee of the Australian Institute of Sport.

Subjects were requested not to consume caffeine or alcohol for 24 h before data collection sessions, and were also asked to abstain from vigorous exercise in this time frame, to avoid known causes of altered proprioception.

Data collection

The AMEDA was used to collect discrimination scores representing subject sensitivity to small differences in extent of ankle inversion. The design of the AMEDA has been documented previously.⁵ The apparatus requires shoulder-width stance, with the tested foot centred on a tilt plate with an axle beneath running in the long axis of the foot. Subjects initiate inversion movements on the tilt plate, from horizontal down to a computer-determined stop point, before returning the plate to the horizontal position.

Before data collection, subjects were provided with five familiarisation sets on the AMEDA. Each set comprised the five deepening inversion extent stimuli (10°, 11°, 12°, 13° and 14° from horizontal), each accompanied by verbal feedback as to the corresponding numerical tilt plate position, where “1” was the least inversion (10°) and “5” the greatest inversion movement (14°). Subjects then entered the data collection phase.

All movement discrimination testing was performed with the subject barefoot, and comprised computer-randomised sets of 50 inversion extent stimuli. No feedback was provided as to the correctness of the provided response. Only one completed attempt at each movement was allowed, and subjects were asked to provide the number that they thought represented the plate position for that movement. Subject responses were then entered into a computer, which in turn reprogrammed the tilt-plate stopper for the next randomised movement.

Measurements of movement discrimination were recorded for both ankles before and after injection of either local anaesthetic (2% lignocaine hydrochloride without adrenaline) or normal saline. Both ankles were assessed twice for control (non-injected) data. All subjects received one injection into each ankle, and no subject received the same injectant twice.

On the initial visit, both ankles were control tested. On the second visit, one ankle was control tested and then the other ankle was tested after injection of either saline or local anaesthetic (figs 1 and 2).

On the third visit, control testing was performed on the ankle injected during the second visit, then the other ankle was tested after injection of the substance not administered on the previous visit. Figure 3 outlines the trial protocol.

Figure 2 Example of subject being tested on AMEDA (active movement extent discrimination apparatus). Informed consent was obtained for publication of this figure.

Figure 3 Trial protocol. S, saline; LA, local anaesthetic.

All ankle joint injections and testing sequences were randomly assigned before the procedure, using a permuted four-block randomisation protocol. The subjects and all researchers involved were blinded as to the nature of the injectant. Disposable syringes were coded and filled with the appropriate substance by a research assistant not directly involved in the research. The total volume injected was 2 ml for both injectants. Injections were administered during visits two and three, by an experienced musculoskeletal radiologist (MT) under ultrasound guidance after betadine preparation (fig 1). There was no anaesthesia of the skin or subcutaneous tissues, and delivery of the injectants only proceeded upon confirmation of an intra-articular needle-tip position. All materials were disposed of after one use, in the appropriate sharps and biohazard containers according to Occupational Health & Safety Administration guidelines. Subjects were asked to wait for 10 min after the injection, while performing gentle active range of motion through the ankle joint to allow even intra-articular distribution of the injectant. Subjects then proceeded to AMEDA testing for data collection. During the second and third visits, when injections were administered, subjects were asked, after data collection, which substance they thought they had received.

At all times during the visits involving joint injections, subjects were monitored for adverse events, and were provided with medical clearance and directions about home management of any minor ailments by the primary researcher (SD) before leaving each session. Subjects were followed up by telephone interview conducted 2 days after each injecting session, to enquire about any problems or concerns.

Figure 4 Mean ankle movement discrimination scores from the initial test session, and from later sessions for the ankles injected with anaesthetic, normal saline and for the corresponding control leg on the opposite side of the body. Chance discrimination is 0.5 and perfect discrimination 1.0. Error bars show one standard error.

Statistical analysis

Raw scores from the AMEDA were collated and cast into 5×5 matrices representing the frequency with which each response was used for each stimulus—for example, the number of times a “2” response was used when stimulus 1 was presented. Thereafter, non-parametric signal detection analysis was used to generate receiver operating characteristic curves. This was done by taking the pairwise combinations of ankle inversion extent stimuli 1 and 2, 2 and 3, 3 and 4, and 4 and 5, and treating the first of each pair as the “noise” and the second as the “signal” for signal detection analysis purposes. Using the receiver operating characteristic subroutine in SPSS V13 for Windows, receiver operating characteristic curves were drawn with the stimulus pair entered as the state variable and the response given entered as the continuous variable. Mean area under these curves (AUC) was used as a discrimination score, with a possible maximum AUC of 1.0 for a perfect discrimination and 0.5 representing chance responding. Thus on each of the three testing occasions, a discrimination score was generated for each foot, and the randomisation code then used to determine whether the foot had received saline or local anaesthetic.

A 3×2 repeated measures analysis of variance was first undertaken on the data, examining for differences between the three measurement occasions, left and right ankles, and any interactions. Thereafter, *t* tests were conducted on the discrimination scores for legs injected with saline or local anaesthetic, and the corresponding control leg on the opposite side of the body.

Power analysis indicated that the study had 80% power to detect as significant differences between conditions of the order of 0.6 SD units, or 0.03 AUC units, an effect size smaller than that detected with previous interventions.

RESULTS

The results of the side $\times$ visit analysis (injection status not considered) showed no significant difference between the mean left leg and right leg discrimination scores (0.68 and 0.67, respectively; $F_{1,20} = 0.46$, $p = 0.51$) nor was any interaction term involving the side factor significant. There was, however, an increase of 0.028 AUC units ($F_{1,20} = 8.52$, $p = 0.008$) in mean scores between the initial and later visits, implying a significant learning effect. The mean discrimination score on the first visit was 0.655, rising to 0.685 and 0.679 for visits two and three, respectively (fig 4).

The mean discrimination score after injection of local anaesthetic was 0.689, which was not significantly different from that found for the control leg on the same visit (0.687; $t_{20, df} = 0.17$, $p = 0.87$). After injection of normal saline, the mean discrimination score was 0.674 (0.682 in the control leg), with the difference again not significant ($t_{20, df} = -0.25$, $p = 0.80$).

There was no significant difference in control for saline versus control for local anaesthetic (means 0.682 and 0.687, respectively), and saline versus local anaesthetic mean discrimination scores (0.674, 0.689) were also not significantly different.

Calculation of bivariate correlation coefficients between the discrimination scores for ankles that had received normal saline or local anaesthetic and their other-side control showed Pearson's *r* of 0.44 ($p = 0.04$) for both, indicating that the ranking of goodness of discrimination performance tended to be preserved, regardless of injection status. The correlation between one injected and one control ankle was similar to the correlation between two normal ankles (0.48) on the same test.²⁶

Finally, because subjects “felt” nothing, 75% guessed saline to be the injectant after the first injection, with subsequent

accuracy of this guess being 30%. Guesses were more evenly distributed at the final visit, although subjects were no better at correctly identifying the injectant received.

One subject experienced paraesthesia in the cutaneous distribution of the deep peroneal nerve after the final injection; however, this had fully resolved 9 days later. No other adverse effects were documented.

DISCUSSION

Neither intra-articular anaesthetic nor an equivalent amount of normal saline had any significant effect on ability to discriminate between small differences in the extent of active ankle movement. The only significant effect detected was an overall improvement in scores from the first to second test trials, an effect attributed to increased test familiarity.

To date, this is the only study to have evaluated proprioception after specifically isolated anaesthesia of the intra-articular mechanoreceptors of the ankle joint. The safety of ankle joint anaesthesia in terms of altered postural control and any subsequently heightened risk of ankle injury has not been previously documented, despite both the high community incidence of ankle injuries and the frequency of ankle injections in sports medicine.

The only large series documenting the use of local anaesthetic in the sports setting has been published by Orchard.²⁷ Although there are some conditions (eg, iliac crest contusions or low-grade acromioclavicular joint sprains) in which local anaesthesia is generally considered safe and justified to allow participation in high-level sport, it is probably considered by most sports physicians that intra-articular injections of the knee and ankle joints, or the smaller joints of the foot, are best avoided in most circumstances. The incidence and outcomes of such injections are largely unknown. Furthermore, the National Collegiate Athletics Association and Australasian College of Sports Physicians are the only two major sporting administrative bodies to have published guidelines or policy statements for the use of local anaesthetic in sport.^{28–29} Both leave the decision to the treating physician.

Simulated ankle joint effusions (10 ml) have also been researched, demonstrating motoneurone excitability within ankle-spanning muscle groups, postulated as a necessary

stabilising reaction to control posture and locomotion.³⁰ In a similar study, decreases in ankle plantarflexion torques and peroneus longus activation were found,³¹ in keeping with similar, well-documented findings of arthrogenic muscle inhibition of the quadriceps muscle group after simulated knee joint effusions.³² Subsequently, the question as to whether autogenic muscle inhibition arises from the intracapsular effusion, or from the extracapsular oedema, chemical mediators and ligamentous disruption that classically follows ankle injury, remains unclear.

In targeting the ankle joint mechanoreceptors in isolation, while ensuring no infiltration of the surrounding soft tissues or ligamentous structures with local anaesthetic or saline, we have not been able to detect any statistically significant changes in movement discrimination scores after intra-articular injection of local anaesthetic or saline. The confirmation of intra-articular injections by using ultrasound guidance and at clinically relevant doses and volumes strongly suggests that the safety of ankle joint anaesthesia is acceptable—at least from a proprioceptive point of view.

Subjects were not aware that they would be asked to name the injectant that they thought they had received after the initial post-injection data collection. Although many nominated the same substance at the final visit (while not being permitted to change previous nominations), there was no evidence of correct identification of the injectant that could be construed to have affected their discrimination scores during the study.

In a finding similar to that from research on anaesthesia of the knee joint²⁴ and metacarpophalangeal joints,²⁵ we have failed to show deleterious proprioceptive effects after ankle joint anaesthesia. In using a self-initiated movement requiring interaction with the environment, our apparatus has created a greater challenge to the ankle movements underlying the postural control system—an aspect questioned in relation to studies using single-leg stance as the outcome measure. Despite the use of more functionally relevant methodology, the findings here complement results from previous research on anaesthesia of the lateral ankle ligament, and together suggest that a more dominant input from afferent systems outside the joint, such as visual input and musculotendinous mechanoreceptors, gives a robustness to proprioception at the ankle joint that normal clinical amounts of injectant do not affect.

What is already known on this topic

- Ankle injuries are one of the most common reasons for missed sporting participation.
- Intra-articular injection of the ankle joint is a common clinical procedure.
- No previous studies have investigated the safety of intra-articular injections of the ankle joint in relation to proprioception.

What this study adds

- Neither intra-articular injection of 2 ml 2% lignocaine nor injection of an equivalent volume of saline affects discrimination scores on the active ankle movement AMEDA test.
- At clinical doses, injections of local anaesthetic into the ankle joint are unlikely to significantly affect proprioception and subsequently heighten injury risk.

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