Effectiveness of Dry Needling in Managing Mechanical Low Back Pain in Fast Bowlers

Dr Mayank Pushkar[1], Dr Neha J Sydney[2]
[1]*Sports Physiotherapist, Indian Physically Handicapped Cricket Team, India*
[2]*Sports Physiotherapist, Indian Women's Deaf Cricket Team, India*

***Abstract*—Background. Mechanical low back pain (LBP) is among the most common and performance-limiting musculoskeletal complaints in cricket fast bowlers, in whom repetitive lumbar hyperextension, rotation and high ground-reaction forces predispose the paraspinal and pelvic musculature to overload and myofascial trigger-point formation. Dry needling (DN) targets myofascial trigger points and has demonstrated short-term benefit in other LBP populations, but evidence in athletic fast-bowling cohorts is limited.**

Objective. To evaluate the effect of a four-week trigger-point DN programme on pain, disability, pressure pain sensitivity, lumbar mobility and sport-specific function in fast bowlers with mechanical LBP.

Methods. In a single-group, quasi-experimental pre–post design, 30 male fast/medium-fast bowlers (mean age 25.2 ± 4.4 years) with non-specific mechanical LBP (>4 weeks; Numeric Pain Rating Scale [NPRS] ≥ 4; palpable lumbar trigger points) received DN to the quadratus lumborum, erector spinae, lumbar multifidus and gluteus medius twice weekly for four weeks (eight sessions). The NPRS and Oswestry Disability Index (ODI; co-primary), and pressure pain threshold (PPT), lumbar flexion range of motion (ROM) and the Patient-Specific Functional Scale (PSFS; secondary) were assessed at baseline (Day 0) and at the end of Week 4. Within-group change was analysed with paired-samples t-tests ($\alpha = 0.05$); Cohen's dz quantified effect size.

Results. All outcomes improved significantly (all $p < 0.001$). NPRS decreased by 2.9 points (95% CI −3.3 to −2.5; dz = −3.0) and ODI by 14.3 percentage points (−15.9 to −12.7; dz = −3.3); 28/30 participants (93%) met the ≥ 2-point NPRS minimal clinically important difference and 16/30 (53%) returned to the minimal-disability ODI category. PPT increased by 1.08 kg/cm² (dz = 3.5), lumbar flexion ROM by 1.29 cm (dz = 3.4) and PSFS by 2.83 points (dz = 4.0). No adverse events were reported.

Conclusion. A four-week trigger-point DN programme was associated with clinically meaningful reductions in pain and disability and with improvements in pressure pain sensitivity, lumbar mobility and sport-specific function in fast bowlers with mechanical LBP. Because the study lacked a control group, these findings are preliminary and require confirmation in randomised controlled trials with longer follow-up.

***Index Terms*—dry needling; low back pain; cricket; fast bowling; myofascial trigger points; sports physiotherapy.**

Abbreviations: NPRS, Numeric Pain Rating Scale; ODI, Oswestry Disability Index; PPT, pressure pain threshold; ROM, range of motion; PSFS, Patient-Specific Functional Scale; LBP, low back pain; DN, dry needling; MTrP, myofascial trigger point; MCID, minimal clinically important difference; CI, confidence interval; SD, standard deviation.

I. INTRODUCTION

Fast bowling is one of the most physically demanding skills in cricket and is consistently identified as a leading source of musculoskeletal injury in the sport. The delivery stride couple's rapid lumbar extension, lateral flexion and rotation with ground-reaction forces of several times body weight, generating large and repetitive loads across the lumbar spine and pelvis. Over a season, a bowler may deliver many thousands of balls, and this cumulative loading places the lumbar region at particular risk of overload injury. [1,2]

Within this spectrum, non-specific mechanical low back pain (LBP) is especially common and frequently limits training volume, match availability and performance. The combination of repeated end-range loading and sustained eccentric demand on the paraspinal and pelvic stabilisers — notably the quadratus lumborum, erector spinae, lumbar multifidus and gluteal muscles — promotes muscular fatigue, altered motor control and the development of myofascial trigger points (MTrPs). [3,4,5] MTrPs are hyperirritable nodules within taut bands of skeletal muscle that are painful on compression, refer pain in characteristic patterns and are associated with local biochemical and electrophysiological changes that sustain peripheral and, over time, central sensitisation. [6,7]

Dry needling (DN) is a skilled physiotherapy technique in which a thin filiform needle is inserted directly into an MTrP, typically to elicit a local twitch response. Proposed mechanisms include mechanical disruption of the dysfunctional motor end-plate region, normalisation of spontaneous electrical activity, improved local blood flow and washout of nociceptive and inflammatory mediators, and segmental and supraspinal modulation of pain. [6,8,9] These effects provide a plausible physiological rationale for using DN to address the myofascial component of mechanical LBP.

Systematic reviews and meta-analyses support DN as an effective adjunct for myofascial pain across several body regions, with the most consistent evidence for short-term reductions in pain and improvements in pressure pain threshold. [10,11,12] In LBP specifically, pooled analyses suggest that DN, particularly when combined with other physiotherapy, reduces pain and disability in the short term, although effect sizes vary and the quality of the evidence is frequently limited. [13,14,15] Mechanistic work further indicates that DN of the lumbar multifidus can alter muscle function and reduce nociceptive sensitivity in responders. [15]

Despite this growing literature, most trials have enrolled general, sedentary or office-based populations. Evidence in athletes — and in fast bowlers in particular, whose rehabilitation must restore not only pain-free status but also the lumbar mobility and trunk function required for high-velocity bowling — remains sparse. Few studies have evaluated DN against a multidimensional outcome set that captures pain, disability, tissue sensitivity, spinal mobility and sport-specific function simultaneously in this group.

The present study therefore aimed to evaluate the effect of a standardised four-week trigger-point DN programme on pain (NPRS), disability (ODI), pressure pain threshold, lumbar flexion range of motion and sport-specific function (PSFS) in fast bowlers with mechanical LBP. We hypothesised that DN would produce statistically significant and clinically meaningful within-group improvements across all five outcomes from baseline to the end of the four-week intervention.

II. MATERIALS AND METHODS

2.1 Study design and reporting

This was a single-group, quasi-experimental pre–post interventional study. Each participant served as their own control, with outcomes measured at baseline (Day 0) and after the four-week intervention (end of Week 4). The study is reported in line with the TREND statement for non-randomised evaluations of behavioural and public-health interventions. [22] The study was conducted at [setting] between [start date] and [end date].

2.2 Ethical approval

The study protocol was approved by the [Institutional Review Board / Ethics Committee, approval number XXXX] and was conducted in accordance with the principles of the Declaration of Helsinki. All participants provided written informed consent before enrolment after receiving a full explanation of the procedures, potential risks and their right to withdraw at any time.

2.3 Participants and sampling

Thirty male fast or medium-fast bowlers with mechanical (non-specific) LBP were recruited by purposive sampling from [recruitment source, e.g., local cricket clubs and academies]. Eligibility was confirmed by a qualified physiotherapist following history-taking and physical examination.

Inclusion criteria: male fast/medium-pace bowlers aged 18–35 years; mechanical LBP of more than four weeks' duration; baseline NPRS $\geq$ 4/10; and at least one palpable, reproducible active myofascial trigger point in the lumbar paraspinal or related musculature.

Exclusion criteria: specific spinal pathology (vertebral fracture, symptomatic disc prolapse with radiculopathy, infection or tumour); recent spinal surgery; needle phobia; bleeding disorder or current anticoagulant therapy; and any neurological deficit.

2.4 Sample size

A sample of 30 participants was based on feasibility within the recruitment period and is consistent with comparable pilot and quasi-experimental physiotherapy studies. For a two-tailed paired-samples t-test at $\alpha = 0.05$, a sample of 30 provides approximately 80% power to detect a within-subject effect size of Cohen's dz ≈ 0.53 (a moderate effect), which was considered the smallest difference of clinical interest. [23] An a priori sample-size justification specific to the primary outcome should be inserted if a formal power analysis was performed.

2.5 Intervention: dry needling protocol

All participants received trigger-point DN delivered by a physiotherapist trained and credentialed in the technique. Treatment targeted active MTrPs in the quadratus lumborum, erector spinae (longissimus and iliocostalis), lumbar multifidus and gluteus medius. After skin preparation with an antiseptic, sterile single-use filiform needles (0.25 × 40 mm and 0.30 × 50 mm, selected according to the target muscle and tissue depth) were inserted into the MTrP. A pistoning ("sparrow-pecking") technique was used to elicit local twitch responses, after which the needle was retained for approximately ten minutes. Participants received two sessions per week for four consecutive weeks, for a total of eight sessions. Bowlers were permitted to continue their usual training as tolerated; concurrent treatments were [recorded / standardised / not permitted — specify].

2.6 Outcome measures

Two co-primary and three secondary outcomes were assessed at baseline and at the end of Week 4 by [an assessor independent of the treating clinician / specify blinding].

Numeric Pain Rating Scale (NPRS; primary). Pain intensity over the preceding 24 hours was rated from 0 (no pain) to 10 (worst imaginable pain). The NPRS is a valid and reliable measure of pain intensity, with a minimal clinically important difference (MCID) of approximately 2 points. [16]

Oswestry Disability Index (ODI; primary). LBP-related disability was measured with the ODI and expressed as a percentage (0–100%), categorised as minimal (0–20%), moderate (21–40%), severe (41–60%) or crippling (61–100%). [17]

Pressure pain threshold (PPT; secondary). PPT was recorded with a handheld pressure algometer over the most tender lumbar MTrP and expressed in kg/cm²; higher values indicate reduced mechanical sensitivity. [18]

Lumbar flexion range of motion (ROM; secondary). Lumbar flexion was assessed in centimetres using the Modified–Modified Schober technique, with larger values indicating greater mobility. [19]

Patient-Specific Functional Scale (PSFS; secondary). Each participant nominated three sport-relevant activities limited by their LBP and rated each from 0 (unable to perform) to 10 (able to perform at the pre-injury level); the mean of the three ratings was used. [20]

2.7 Statistical analysis

Continuous variables are summarised as mean ± SD with range, and categorical variables as counts and percentages. The distribution of change scores was inspected before analysis. For each outcome, the within-group change from baseline to Week 4 was tested with a two-tailed paired-samples t-test, with statistical significance set at $p < 0.05$. Mean changes are presented with 95% confidence intervals. The magnitude of change was expressed as Cohen's dz (the mean change divided by the SD of the change scores), interpreted as small (0.2), medium (0.5) or large (0.8). [23] As a sensitivity analysis, the non-parametric Wilcoxon signed-rank test was applied to each outcome. Responder analyses calculated the proportion of participants achieving the NPRS MCID (≥ 2-point reduction) and a clinically relevant shift in ODI category. Analyses were performed in Python 3 (SciPy, NumPy and pandas); a complete-case approach was used.

III. RESULTS

3.1 Participant characteristics

Thirty male fast/medium-fast bowlers were enrolled and all completed the four-week programme, with no dropouts and no reported adverse events. Baseline characteristics are presented in Table 1. The cohort had a mean age of 25.2 ± 4.4 years and a mean BMI of 24.1 ± 3.8 kg/m², with a mean of 6.6 ± 3.6 years of bowling experience and a mean symptom duration of 8.7 ± 3.3 months. Twenty-five participants (83%) were right-arm bowlers and five (17%) were left-arm bowlers.

Table 1. Baseline characteristics of participants (n = 30).

Characteristic	Mean ± SD	Range (min–max)
Age (years)	25.2 ± 4.4	18–32
Height (cm)	176.0 ± 7.6	165–191
Weight (kg)	74.4 ± 11.0	58–92
BMI (kg/m²)	24.1 ± 3.8	17.5–31.6
Bowling experience (years)	6.6 ± 3.6	2–14
Symptom duration (months)	8.7 ± 3.3	3–15
Sex	Male: 30 (100%)	—
Bowling arm	Right: 25 (83%) · Left: 5 (17%)	—

SD, standard deviation; BMI, body mass index.

3.2 Primary outcomes: pain and disability

Pain intensity decreased markedly over the four weeks. Mean NPRS fell from 6.4 ± 0.9 at baseline to 3.5 ± 1.4 at Week 4, a mean reduction of 2.90 points (95% CI −3.26 to −2.54; $t(29) = -16.55$, $p < 0.001$), corresponding to a very large effect (dz = −3.02). Twenty-eight of 30 participants (93%) achieved at least the 2-point MCID for the NPRS.

Disability also improved substantially. Mean ODI decreased from 33.9 ± 6.2% to 19.6 ± 5.8%, a mean reduction of 14.30 percentage points (95% CI −15.94 to −12.66; $t(29) = -17.79$, $p < 0.001$; dz = −3.25). At baseline all participants were in the moderate (n = 25) or severe (n = 5) disability categories, whereas after the intervention 16 participants (53%) had moved into the minimal-disability category (≤ 20%) and the remaining 14 were classified as moderate.

3.3 Secondary outcomes: sensitivity, mobility and function

All three secondary outcomes improved significantly. Pressure pain threshold increased from 2.87 ± 0.45 to 3.96 ± 0.51 kg/cm² (mean change +1.08, 95% CI 0.97 to 1.20; $t(29) = 19.16$, $p < 0.001$; dz = 3.50), indicating reduced mechanical sensitivity over the treated tissue. Lumbar flexion ROM increased from 4.54 ± 0.52 to 5.83 ± 0.63 cm (mean change +1.29, 95% CI 1.15 to 1.43; $t(29) = 18.87$, $p < 0.001$; dz = 3.44). Sport-specific function showed the largest relative change: the PSFS rose from 4.28 ± 0.75 to 7.10 ± 0.89 (mean change +2.83, 95% CI 2.56 to 3.09; $t(29) = 22.00$, $p < 0.001$; dz = 4.02), with 28 of 30 participants (93%) improving by at least 2 points.

The non-parametric Wilcoxon signed-rank test confirmed the parametric findings for every outcome (all $p < 0.001$). The pre–post comparisons for all five outcomes are summarised in Table 2 and illustrated in Figures 1 and 2.

Table 2. Pre–post comparison of outcome measures (paired-samples t-test, n = 30).

Outcome (units)	Baseline (mean ± SD)	Week 4 (mean ± SD)	Mean change (95% CI)	p-value	Cohen's dz
Primary outcomes					
NPRS — pain (0–10)	6.4 ± 0.9	3.5 ± 1.4	−2.90 (−3.26, −2.54)	< 0.001	−3.02
ODI — disability (%)	33.9 ± 6.2	19.6 ± 5.8	−14.30 (−15.94, −12.66)	< 0.001	−3.25
Secondary outcomes					
PPT (kg/cm²)	2.87 ± 0.45	3.96 ± 0.51	+1.08 (0.97, 1.20)	< 0.001	3.50
Lumbar flexion ROM (cm)	4.54 ± 0.52	5.83 ± 0.63	+1.29 (1.15, 1.43)	< 0.001	3.44
PSFS — function (0–10)	4.28 ± 0.75	7.10 ± 0.89	+2.83 (2.56, 3.09)	< 0.001	4.02

Values are mean ± SD. p-values are from two-tailed paired-samples t-tests; all t statistics had 29 degrees of freedom (range of $|t|$ = 16.6–22.0). The sign of Cohen's dz follows the direction of change. For NPRS and ODI a decrease denotes improvement; for PPT, ROM and PSFS an increase denotes improvement. CI, confidence interval; NPRS, Numeric Pain Rating Scale; ODI, Oswestry Disability Index; PPT, pressure pain threshold; ROM, range of motion; PSFS, Patient-Specific Functional Scale.

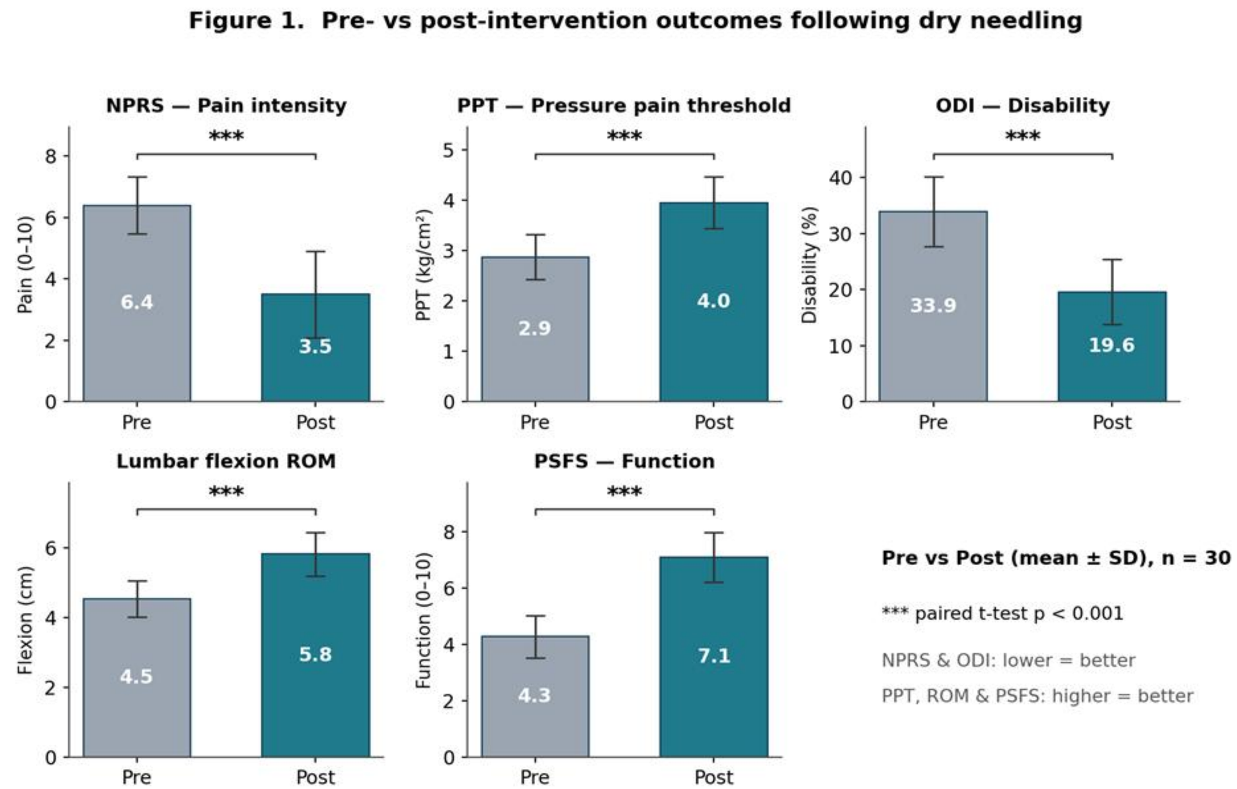

Figure 1. Pre- versus post-intervention outcomes following the four-week dry needling programme (mean ± SD, n = 30). For each measure, baseline (Pre) and Week 4 (Post) values are shown; *** denotes $p < 0.001$ (paired-samples t-test). NPRS and ODI decrease with improvement, whereas PPT, ROM and PSFS increase with improvement.

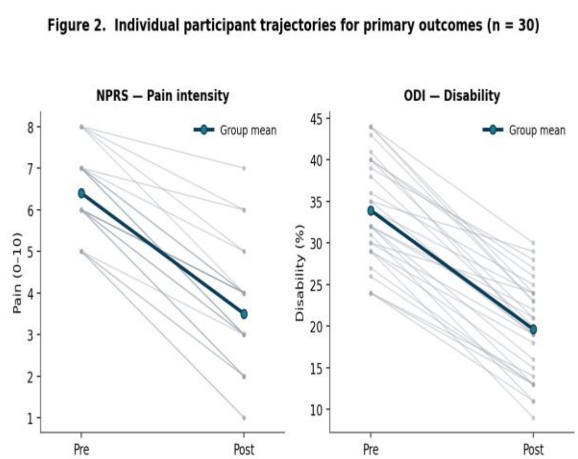

Figure 2. Individual participant trajectories for the co-primary outcomes (n = 30). Faint grey lines represent individual bowlers; the bold navy line represents the group mean. Every participant improved on both the NPRS (pain) and the ODI (disability) from baseline to Week 4.

IV. DISCUSSION

In this single-group study of fast bowlers with mechanical LBP, a four-week trigger-point DN programme was associated with statistically significant and clinically meaningful improvements across all five outcomes. Pain and disability both decreased substantially, and the secondary measures of pressure pain threshold, lumbar flexion mobility and sport-specific function all improved. Importantly, the change in pain met the established MCID in 93% of participants, and just over half of the cohort moved from moderate or severe disability into the minimal-disability ODI category, suggesting that the statistical changes translated into clinically relevant benefit.

The direction of these findings is consistent with systematic reviews reporting that DN reduces pain and disability and increases pressure pain threshold in myofascial and LBP populations. [10,11,12,13,14] The magnitude of the within-group changes observed here is, however, larger than the typically modest pooled effects reported in controlled trials. This difference almost certainly reflects the uncontrolled design: in the absence of a comparison group, the observed improvement captures not only any specific effect of DN but also the natural history of a self-limiting condition, regression to the mean, placebo and expectation effects, the therapeutic attention inherent in eight supervised sessions, and any benefit from continued sport participation. The results should therefore be read as the total change over the treatment period rather than as an isolated treatment effect.

Several mechanisms may nonetheless contribute to a genuine effect of DN in this population. Eliciting local twitch responses is thought to mechanically disrupt dysfunctional motor end-plates, reduce the spontaneous electrical activity associated with active MTrPs, improve local microcirculation and promote clearance of nociceptive and inflammatory mediators. [6,8,9] The observed increase in pressure pain threshold over the treated tissue is consistent with reduced peripheral sensitisation, and prior work has shown that needling of the lumbar multifidus can change muscle function and lower nociceptive sensitivity in responders. [15] Because the multifidus and quadratus lumborum are central to lumbar stability during the bowling action, normalising their function is mechanistically relevant to this group.

The parallel gains in lumbar flexion ROM and PSFS are particularly relevant to bowlers, for whom successful return to play depends on restoring trunk mobility and confidence in sport-specific tasks rather than pain relief alone. Reduced pain and tissue sensitivity may have permitted greater pain-free movement, which in turn is reflected in the large improvement in self-rated functional capacity. That the PSFS — an individualised, activity-based measure — showed the greatest relative change suggests that participants experienced meaningful improvement in the activities they themselves considered most limited.

From a clinical perspective, these findings support the use of DN as one component of a multimodal physiotherapy programme for bowlers with a clear myofascial contribution to their LBP, rather than as a standalone cure. Contemporary guidelines for LBP emphasise active, exercise-based management, and DN is best positioned as an adjunct that may reduce pain and facilitate engagement with loading, motor-control and biomechanical interventions. [21] Integrating DN within a graded return-to-bowling pathway, and addressing workload management and technique, is likely to be more effective and durable than passive treatment alone.

Strengths of this study include a standardised, clearly described needling protocol, complete follow-up with no dropouts, and a multidimensional outcome set that combined patient-reported measures with a clinician-measured objective marker of tissue sensitivity (PPT) and an objective measure of spinal mobility (ROM), as well as an individualised functional scale relevant to sport.

Nevertheless, several limitations must temper interpretation. First and most importantly, the single-group design without a control or comparison arm precludes any causal attribution; natural history, regression to the mean, placebo and attention effects, and concurrent training cannot be separated from the effect of DN. Second, the absence of randomisation and of participant or assessor blinding introduces the potential for performance and detection bias, particularly for self-reported outcomes. Third, the four-week horizon with no longer-term follow-up means the durability of the improvements is unknown. Fourth, the cohort was drawn from a single setting and comprised exclusively young adult male bowlers within a narrow age range, limiting generalisability to female bowlers, adolescents, and elite or recreational players with different loading profiles. Fifth, no formal correction for multiple comparisons was applied across the five outcomes, although all effects were highly significant. Finally, the comparatively small sample, while adequately powered for large within-group effects, limits the precision of subgroup or responder estimates.

Future research should evaluate DN in adequately powered randomised controlled trials that include a sham-needling or standard-care comparison, incorporate longer follow-up to assess durability and recurrence, and add performance and biomechanical outcomes alongside clinical measures. Trials in female and adolescent bowlers, dose-response studies, and direct comparisons or combinations of DN with exercise-based rehabilitation would further clarify the role of DN in this population.

V. CONCLUSION

A standardised four-week trigger-point dry needling programme was associated with clinically meaningful reductions in pain and disability and with improvements in pressure pain sensitivity, lumbar mobility and sport-specific function in male fast bowlers with mechanical low back pain. While these preliminary results are encouraging and support the use of dry needling as an adjunct within multimodal physiotherapy, the uncontrolled design means causal inference is not possible. Randomised controlled trials with appropriate comparison groups and longer follow-up are needed to confirm these findings and to define the role of dry needling in the management of low back pain in fast bowlers.

REFERENCES

[1] Stretch RA. Cricket injuries: a longitudinal study of the nature of injuries to South African cricketers. Br J Sports Med. 2003;37(3):250–253.

[2] Orchard JW, Kountouris A, Sims K. Incidence and prevalence of elite male cricket injuries using updated consensus definitions. Open Access J Sports Med. 2016;7:187–194.

[3] Olivier B, Stewart AV, McKinon W. Injury and lumbar reposition sense in cricket pace bowlers in neutral and pre-bowling postures. J Sport Rehabil. 2015;24(1):17–26.

[4] Ranson CA, Burnett AF, Kerslake R, Batt ME, O'Sullivan PB. An investigation of lumbar spine morphology and pars interarticularis defects in elite cricket fast bowlers. Br J Sports Med. 2008;42(10):809–815.

[5] Bayne H, Elliott B, Campbell A, Alderson J. Lumbar load in adolescent fast bowlers: a prospective injury study. J Sci Med Sport. 2016;19(2):117–122.

[6] Simons DG, Travell JG, Simons LS. Travell & Simons' Myofascial Pain and Dysfunction: The Trigger Point Manual. 2nd ed. Baltimore: Williams & Wilkins; 1999.

[7] Shah JP, Thaker N, Heimur J, Aredo JV, Sikdar S, Gerber L. Myofascial trigger points then and now: a historical and scientific perspective. PM R. 2015;7(7):746–761.

[8] Dunning J, Butts R, Mourad F, Young I, Flannagan S, Perreault T. Dry needling: a literature review with implications for clinical practice guidelines. Phys Ther Rev. 2014;19(4):252–265.

[9] Cagnie B, Dewitte V, Barbe T, Timmermans F, Delrue N, Meeus M. Physiologic effects of dry needling. Curr Pain Headache Rep. 2013;17(8):348.

[10] Kietrys DM, Palombaro KM, Azzaretto E, Hubler R, Schaller B, Schlussel JM, et al. Effectiveness of dry needling for upper-quarter myofascial pain: a systematic review and meta-analysis. J Orthop Sports Phys Ther. 2013;43(9):620–634.

[11] Gattie E, Cleland JA, Snodgrass S. The effectiveness of trigger point dry needling for musculoskeletal conditions by physical therapists: a systematic review and meta-analysis. J Orthop Sports Phys Ther. 2017;47(3):133–149.

[12] Liu L, Huang QM, Liu QG, Ye G, Bo CZ, Chen MJ, et al. Effectiveness of dry needling for myofascial trigger points associated with neck and shoulder pain: a systematic review and meta-analysis. Arch Phys Med Rehabil. 2015;96(5):944–955.

[13] Hu HT, Gao H, Ma RJ, Zhao XF, Tian HF, Li L. Is dry needling effective for low back pain? A systematic review and PRISMA-compliant meta-analysis. Medicine (Baltimore). 2018;97(26):e11225.

[14] Liu L, Huang QM, Liu QG, Thitham N, Li LH, Ma YT, et al. Evidence for dry needling in the management of myofascial trigger points associated with low back pain: a systematic review and meta-analysis. Arch Phys Med Rehabil. 2018;99(1):144–152.e2.

[15] Koppenhaver SL, Walker MJ, Su J, McGowen JM, Umlauf L, Harris KD, et al. Changes in lumbar multifidus muscle function and nociceptive sensitivity in low back pain patient responders versus non-responders after dry needling treatment. Man Ther. 2015;20(6):769–776.

[16] Hawker GA, Mian S, Kendzerska T, French M. Measures of adult pain: Visual Analog Scale for Pain (VAS Pain), Numeric Rating Scale for Pain (NRS Pain) and others. Arthritis Care Res (Hoboken). 2011;63(Suppl 11):S240–S252.

[17] Fairbank JC, Pynsent PB. The Oswestry Disability Index. Spine (Phila Pa 1976). 2000;25(22):2940–2952.

[18] Walton DM, MacDermid JC, Nielson W, Teasell RW, Chiasson M, Brown L. Reliability, standard error, and minimum detectable change of clinical pressure pain threshold testing in people with and without acute neck pain. J Orthop Sports Phys Ther. 2011;41(9):644–650.
[19] Tousignant M, Poulin L, Marchand S, Viau A, Place C. The Modified–Modified Schober Test for range of motion assessment of lumbar flexion in patients with low back pain: a study of criterion validity, intra- and inter-rater reliability and minimum metrically detectable change. Disabil Rehabil. 2005;27(10):553–559.
[20] Stratford P, Gill C, Westaway M, Binkley J. Assessing disability and change on individual patients: a report of a patient specific measure. Physiother Can. 1995;47(4):258–263.
[21] Chou R, Deyo R, Friedly J, Skelly A, Hashimoto R, Weimer M, et al. Nonpharmacologic therapies for low back pain: a systematic review for an American College of Physicians clinical practice guideline. Ann Intern Med. 2017;166(7):493–505.
[22] Des Jarlais DC, Lyles C, Crepaz N; TREND Group. Improving the reporting quality of nonrandomized evaluations of behavioral and public health interventions: the TREND statement. Am J Public Health. 2004;94(3):361–366.
[23] Cohen J. Statistical Power Analysis for the Behavioral Sciences. 2nd ed. Hillsdale, NJ: Lawrence Erlbaum Associates; 1988.