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ORIGINAL RESEARCH

Reliability of Entry-Level Athletic Trainers' Palpation Skills of Bony Anatomical Landmarks in the Lumbopelvic Region

Sarah M. Schultz, MSEd, ATC*; Michelle M. Jacobs, MSEd, ATC†; Kara S. Gorgos, MSEd‡; Nicole T. Wasylyk, MSEd, ATC§; Sean Hanrahan, MSEd, ATC||; Bonnie L. Van Lunen, PhD, ATC, FNATA¶
*Indiana Wesleyan University, Marion; †Loyola University of Chicago, IL; ‡University of Buffalo, NY; §University of Wisconsin Sports Medicine Center, Madison; ||Apprentice School, Newport News, VA; ¶Old Dominion University, Norfolk, VA

Context: Accuracy of locating various lumbopelvic landmarks for novice athletic trainers has not been examined.

Objective: To examine reliability of novice athletic trainers for identification of the L4 spinous process and right and left posterior superior iliac spine (PSIS).

Design: Cross-sectional reliability.

Setting: Laboratory.

Patients or Other Participants: Sixteen physically active volunteers participated (age = 22.56 ± 2.67 years, height = 172.0 ± 9.38 cm, mass = 67.39 ± 9.73 kg, body mass index = 22.8 ± 1.97). Four novice athletic trainers (certified < 2 years) served as the testers of interest.

Intervention(s): Subjects were placed prone and 2 expert athletic trainers (certified > 12 years) agreed upon each bony landmark and transferred the palpation markings to contact paper. Each novice athletic trainer palpated the landmarks twice within the same test session and used the same method as the experts for transfer and recording. Novice athletic trainers rotated between subjects after 1 marking trial. Expert marks were transposed over the tester marks to assess distance and agreement.

Main Outcome Measure(s): Independent variables were novice athletic trainer (AT1, AT2, AT3, AT4) and time (Trial 1, Trial 2); dependent variables included distance from the expert marking in millimeters for L4 and PSIS palpations, and agreement within or outside of a designated area for the L4 spinous process. Intraclass correlation coefficients (ICC [2,1]), standard error of measurement, and percent agreement were calculated.

Results: Intratester reliability for L4 ranged from 0.370 to 0.833, right PSIS (RPSIS) ranged from 0.371 to 0.771, and left PSIS (LPSIS) ranged from –0.173 to 0.760. Intertester ICC (2,1) for Trial 1 and Trial 2 were, respectively, 0.319 and 0.466 (L4), 0.213 and 0.002 (RPSIS), and 0.96 and 0.073 (LPSIS). Percent agreement between expert and testers ranged from 18.75%–81.3% for L4 spinous process.

Conclusions: Our results indicate novice athletic trainers are generally poor at reliably locating lumbopelvic anatomical landmarks, and this should be addressed within educational programming.

Key Words: Interrater reliability, intrarater reliability, posterior iliac spine, spinous process, L4

Dr Van Lunen is currently a Professor and Chair of the School of Physical Therapy and Athletic Training at Old Dominion University. Please address all correspondence to Bonnie L. Van Lunen, PhD, ATC, FNATA, School of Physical Therapy and Athletic Training, Old Dominion University, 3118 Health Sciences, Norfolk, VA 23529. bvanlune@odu.edu.

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INTRODUCTION

Low back pain (LBP) is a common condition, affecting approximately two-thirds of the US population at some point within their lifetime[1,2] and is preceded only by the common cold in frequency of complaints heard by primary care physicians.[3] On average, an American worker will miss at least 1 day a year due to LBP.[3] As a result, direct and indirect costs of care (ie, treatment, lost wages, and worker's compensation) for LBP are high, with estimates of direct costs at $100 billion[3,4] and indirect costs at $50 billion.[3] As a whole, expenditures of direct and indirect costs related to LBP have increased 73% between 1997 and 2005.[5,6] To decrease these high costs, clinicians need to be able to effectively assess and treat associated conditions (ie, facet malalignments, muscle imbalances, rotational issues); therefore, the ability to accurately palpate the bony landmarks of the low back is essential.

Several reliability studies for spinal palpation have been conducted by physiotherapists,[7–13] osteopathic students/physicians,[14] and chiropractors[15,16]; however, reliability studies with athletic trainers as examiners have not been documented. The ability to treat low back pathology is within the scope of an athletic trainer's practice, and spinal palpation is 1 of the competencies of the Commission on Accreditation of Athletic Training Education (CAATE).[17] Because of this competency, it is assumed that athletic trainers have the knowledge and skills to accurately palpate the spine and pelvis. However, manipulative therapists and chiropractors who specialize in the spine have been shown to perform spinal palpation poorly.[9,12,18,19] Therefore, the reliability and validity of spinal palpation by athletic trainers needs to be examined, and if necessary, the education of athletic training students in professional programs needs to be addressed. The purpose of this paper was to evaluate the reliability of spinal palpation within and between novice athletic trainers. We hypothesized that percent agreement for categorical assessment would be high (above 83%),[20] intrarater reliability would be good (0.76–0.90),[21] and interrater reliability would be moderate (0.51–0.75).[21]

METHODS

Research Design

A cross-sectional reliability study was conducted to examine intrarater and interrater reliability of 4 novice athletic trainers' palpation skills of 3 lumbopelvic bony landmarks: L4 spinous process, and the left and the right posterior superior iliac spine (PSIS). The determination of accuracy was based on each novice athletic trainer's marks being within or outside a designated area for the L4 spinous process, and the distance from the expert marking was measured in millimeters for L4 and PSIS palpations. Independent variables were tester (AT1, AT2, AT3, AT4) and time (Trial 1, Trial 2).

Participants

We used randomized sampling and criterion sampling to obtain 16 volunteers (11 females; 5 males; age = 22.56 ± 2.67 years, height = 172.0 ± 9.38 cm, mass = 67.39 ± 9.73 kg, body mass index [BMI] = 22.8 ± 1.97) for participation in this study. Participants were screened with a medical questionnaire and were included if they were recreationally active, which was defined as exercising at least 3 times a week. Participants were excluded if they were currently suffering from acute (<4 weeks) LBP, had a BMI > 30, had any visibly identifiable characteristics (eg, birthmark, tattoo, skin lesion), serious spinal pathology, nerve root problem, neurologic symptoms, history of spine surgery, or discomfort in testing position for the 45 minutes of testing (eg, pain, stiffness, shortness of breath). All participants read and signed an informed consent document, and this study was approved by the University Institutional Review Board. Four novice athletic trainers with less than 2 years of athletic training experience and who were currently enrolled in a postprofessional CAATE-accredited athletic training program served as the testers. Two athletic trainers who were certified for more than 12 years were utilized as the experts.

Figure 1. Contact paper transfer alignment.

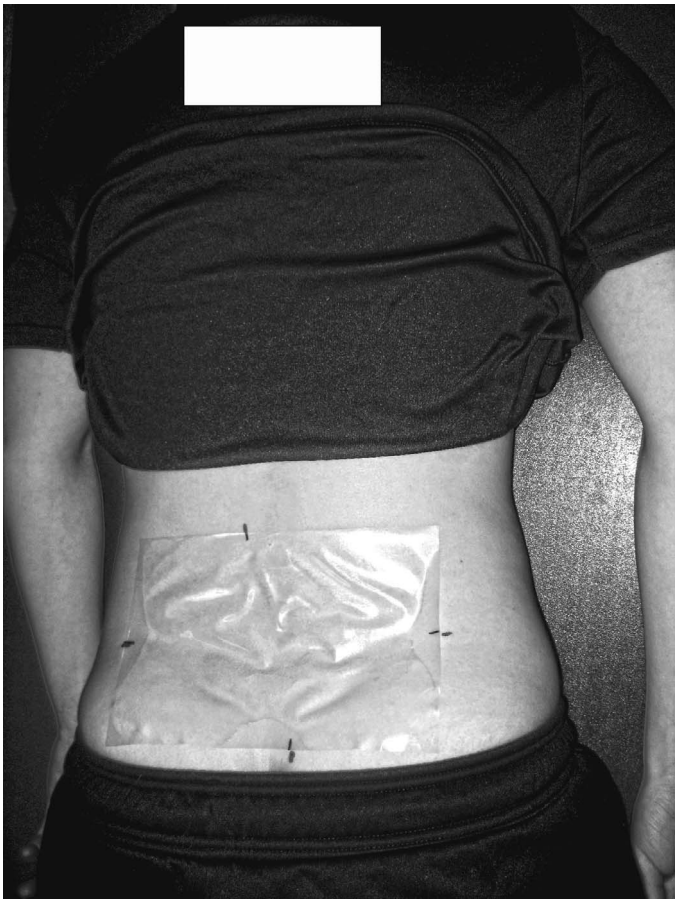
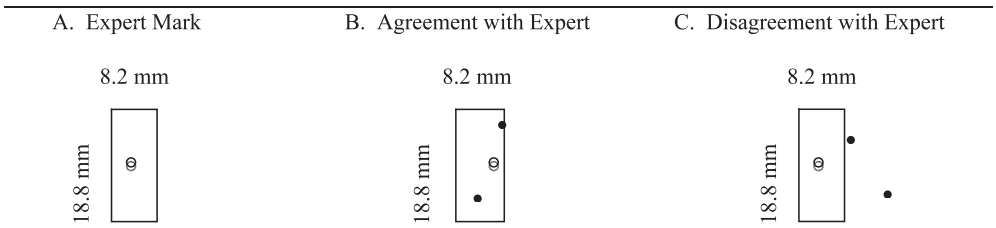


Figure 2. Determination of accuracy.



Procedures

Data were collected in an athletic training facility and within the Clinical Outcome Research Laboratory. Materials used in the study included invisible pens (Globright, Naperville, IL), Chauvet handheld black lights (B & H Foto & Electronics, New York, NY) contact paper, a standard 12-inch ruler, and permanent markers. Rubbing alcohol and gauze pads were used to clean the participant's markings in between novice athletic trainers.

Each participant completed a medical screening questionnaire and was measured for height and weight, which was used to calculate BMI. Each participant was asked to lie prone on a plinth and remain as still as possible throughout testing. The 2 experts independently palpated each participant and then agreed on the center of the most prominent projection of each lumbopelvic landmark. The experts marked each point with an ultraviolet (UV) pen. A piece of 5×8 contact paper was placed on the participant's back over the palpation marks, and 4 alignment markings on the contact paper were then transferred to the participant's back with permanent marker (Figure 1). The experts transferred the UV pen palpation markings onto the contact paper using a UV light for visualization and a permanent marker for the transfer. The contact paper was removed and placed on a transparency in order to clearly read and measure the markings. The participant's back was cleaned with the isopropyl alcohol and the 4 novice athletic trainers began the rotations for palpation.

The novice athletic trainers were randomly allocated to 1 of 4 subjects by choosing an envelope with tester initials inside for each subject. The novice athletic trainers were instructed to utilize the palpation technique which they were taught within their professional athletic training program, as long as the participant remained prone and stationary. The novice athletic trainers were instructed to locate and mark the most prominent point of each bony landmark and followed the same procedure as the experts for marking and transferring marks. The novice athletic trainers rotated between subjects and then began the process again for a second set of markings within the same session. Tables were arranged to blind the novice athletic trainers from seeing the palpation technique(s) that the other testers were using. The novice athletic trainers were also blind to markings of the experts and the other testers.

The distance of the novice athletic trainers' marks from the experts' marks in trials 1 and 2 were measured manually using a standard metric ruler and recorded in millimeters. The distance between Trial 1 and Trial 2 was also measured for each novice athletic trainer. A designated area (Figure 2) was drawn around the expert's L4 palpation marks and utilized to determine percent agreement. This designated area (height: 18.8 mm; width: 8.2 mm) was chosen from a cadaver study.[12]

Statistical Analysis

Data analyses were performed using SPSS (version 21.0; SPSS Inc, Chicago, IL). All data were assessed for normalcy. Interrater and intrarater reliability were determined by calculating the intraclass correlation coefficients (ICCs) with a 2,1 model and a 95% confidence interval. Percent agreement was calculated between novice athletic trainers and experts. Other studies determined rater reliability through calculation of Cohen κ[8,10,12,14,16,18,19] or Cohen κ and percent agreement.[12,14] However, κ could not be utilized for this paper because the predetermined area was based around the experts' mark of the L4 spinous process, therefore leaving no reference standard comparison.[20]

RESULTS

The intratester reliability results for L4, right PSIS, and left PSIS are presented in Table 1. Table 2 presents the intertester reliability for the 3 bony landmarks palpated for both trials. The percent agreement between expert and novice athletic trainers is shown in Table 3. These data indicate that novice athletic trainers have poor to moderate intratester reliability and poor intertester reliability and agreement for palpation in

Table 1. Intra-Rater Reliability for L4 and PSIS

	L4			LPSIS			RPSIS		
	ICC (2,1)	95% CI	SEM (mm)	ICC (2,1)	95% CI	SEM (mm)	ICC (2,1)	95% CI	SEM (mm)
AT1	0.370	−0.136, 0.723	5.46	−0.173	−0.604, 0.338	6.45	0.371	−0.135, 0.724	3.67
AT2	0.750	0.420, 0.905	5.50	0.760	0.438, 0.909	3.32	0.587	0.147, 0.833	3.01
AT3	0.833	0.586, 0.938	4.61	0.202	−0.311, 0.623	5.09	0.563	0.111, 0.822	2.80
AT4	0.667	0.273, 0.870	5.39	0.735	0.391, 0.899	3.82	0.771	0.459, 0.913	3.22

Abbreviations: CI, confidence interval; ICC, intra-class correlation coefficient; LPSIS, left posterior superior iliac spine; RPSIS, right posterior superior iliac spine; SEM, standard error of measurement.

Table 2. Inter-Rater Reliability for L4 and PSIS

	ICC (2,1)	95% CI	SEM (mm)
Trial 1			
L4	0.319	0.078, 0.614	12.10
LPSIS	0.096	−0.092, 0.398	8.35
RPSIS	0.213	−0.007, 0.521	6.24
Trial 2			
L4	0.466	0.215, 0.725	9.47
LPSIS	0.073	−0.107, 0.372	9.21
RPSIS	−0.002	−0.155, 0.278	7.56

Abbreviations: CI, confidence interval; ICC, intra-class correlation coefficient; LPSIS, left posterior superior iliac spine; RPSIS, right posterior superior iliac spine; SEM, standard error of measurement.

the lumbopelvic region (ICC ranges: <0.50 indicates poor, 0.50–0.75 moderate, and >0.75 good reliability).[21] Percent agreement is directly interpretable by researchers, and no range or scale has been indicated.[20] In this paper, the percent agreement is the percent of palpation markings that were inside the predetermined area for the L4 spinous process.

It should be noted that the ICC could potentially be an entire category difference due to the wide CIs (Tables 1 and 2). To account for error, the distances between markings for Trial 1 and Trial 2 were calculated for each novice athletic trainer. These measurements show the consistency of palpation for each novice athletic trainer within him or herself (Table 4).

Table 3. Percent Agreement Values for L4

	Within Tester (%)	With Expert Trial 1 (%)	With Expert Trial 2 (%)
AT1	75.0	56.25	31.25
AT2	75.0	50.00	25.00
AT3	81.3	12.50	6.25
AT4	68.8	18.75	25.00

DISCUSSION

The main findings revealed that novice athletic trainers have poor to moderate intrarater reliability and poor interrater reliability in palpation of lumbopelvic bony landmarks. These findings are supported by previous studies on spinal palpation which examined the rater reliability of physiotherapists palpating L1–L5[12] and the reliability of osteopathic students palpating the PSIS, sacral sulcus, and sacral inferior lateral angle.[18] Both studies reported that intra-examiner reliability was greater than inter-examiner reliability. In addition to determining rater reliability, validity of spinal palpation has been examined in studies using radiographs as the gold standard.[9,15,19,22] Robinson et al[19] examined the intertester reliability and validity by identifying spinous processes of C7 and L5 and reported intertester reliability to be poor for C7 and moderate for L5 spinous process, while the validity was low for both. Harlick et al[9] incorporated a gold reference standard for verification of landmarks by using two-dimensional (2-D) radiographs and reported that physiotherapists had a mean palpation accuracy of 47% across spinal levels (L1, L3, and L5). The variation in lumbar palpation accuracy among the physiotherapists was significant at L3 and L5; however, there is some question as to the accuracy of 2-D as they were reported to lack accuracy which could lead to confounding results. These findings support the need for additional palpation skill development within various health care providers including athletic training.

Verbal feedback may play an important role when teaching palpation skills. Pringle[23] examined retention and acquisition using varied verbal feedback, which included knowledge of results, for teaching prone spring testing on the spine. He reported that the groups receiving intermittent and frequent verbal feedback had the greatest retention. The group with constant verbal feedback showed accuracy in performing spring testing, but revealed poor retention of the skill. These results suggest that frequent verbal feedback can result in improvements in performance accuracy and retention. Furthermore, Pringle[23] reported that sex and body types may affect the rate of learning and retention. Males typically have more muscle mass, which may make palpating bony landmarks more difficult. Additionally, individuals with limited adipose tissue are typically easier to palpate than someone who is overweight or obese. In this paper, the effect of body type on palpation reliability was controlled by excluding participants with a BMI > 30; however, a lower BMI may not have corresponded to decreased adipose tissue over the palpatory sites. Other factors such as lordotic curvature and muscle mass may also contribute to the ease or difficulty of locating the landmarks. It is, however, important to note that athletic trainers provide medical services for individuals of varying body types and sexes; therefore, the ability to locate spinal landmarks regardless of overlying tissue is essential.

Other investigators[12,13] have examined the size, shape, and dimensions of individual landmarks. Phillips et al[13] studied strategies to improve physiotherapy students' ability to accurately locate selected thoracic and lumbar spinal segments. They reported that enhancing students' manual examination training with supplementary anatomical information on shapes and length of tips of spinous processes increased their accuracy in locating T12 and L3 spinal

Table 4. Distance in Millimeters Between Trial 1 and Trial 2 Markings (Mean ± SD; N = 4)

	AT1	AT2	AT3	AT4
L4	6.44 ± 5.97	6.50 ± 4.21	5.75 ± 4.31	7.25 ± 5.41
LPSIS	7.88 ± 7.13	4.13 ± 3.88	7.75 ± 5.77	8.50 ± 6.97
RPSIS	6.06 ± 4.73	4.94 ± 3.49	7.06 ± 5.08	5.81 ± 4.82

Abbreviations: LPSIS, left posterior superior iliac spine; RPSIS, right posterior superior iliac spine.

segments. McKenzie and Taylor[12] reported average dimensions of the L1–L5 spinous processes from a convenience sample of 10 adult human skeletons, which may be used as a resource for providing information on the general dimensions of bony landmarks to assist in the palpation education of clinicians. Athletic training educators should take advantage of this knowledge on the lumbar vertebrae dimensions and use these dimensions to interpret students' accuracy of lumbar spinal palpation. In addition, instructors should take into account that the spinous process is not a point, but an area, and give a margin for error when assessing spinal palpation.[24] Future research should be conducted in an attempt to find average dimensions for other anatomic bony landmarks.

Patient positioning and movement should be considered when teaching spinal palpation. Several methods are used to palpate lumbopelvic bony landmarks during sacroiliac dysfunction, innominate bone, and sacral base position tests.[25] Tong et al[25] used a seated flexion test, standing stork test, and standing flexion test to assess sacroiliac dysfunction in addition to sacral base position with trunk flexion and extension, supine anterior superior iliac spine symmetry, and supine medial malleolus symmetry to assess innominate bone and sacral base position tests. All of these tests included palpation of the lumbopelvic region in various positions and some aspect of patient movement. Future studies should determine how patient positioning and movement plays a role in reliability of spinal palpation.

Overall, athletic training educators should consider giving frequent, but not constant, verbal feedback to students while teaching spinal palpation, or any type of anatomical palpation, in an attempt to facilitate retention. Students should learn and practice spinal palpations on individuals with a variety of body types. Practice of spinal palpation should occur in both the didactic setting and during clinical experiences. Preceptors should be held responsible for reinforcing the necessity for athletic training students to practice spinal palpation. Athletic training students should also learn about the size, shape, and dimensions of individual vertebrae and be given supplementary anatomical information on shapes and length of tips of spinous processes.[13] It is therefore suggested that educators utilize the dimensions of L1–L5 spinous processes[12] and create template boxes to initially guide spinal palpation accuracy. Instructors should also take into account that spinous processes are not a point, but an area, and give a margin for error when assessing spinal palpation.[24]

Future research should examine more than 1 patient position to locate lumbopelvic bony landmarks and attempt to determine key phrases to use for verbal feedback. Investigators should also seek to establish standardized areas for bony landmarks to assist with identification during palpation. Educational research should focus on the use of such standardized areas as feedback when the skill is initially taught, as well as in the assessment of the skill.

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