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Authors
Levine, David
Walker, J Randy
Marcellin-Little, Denis J
et al.

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Detection of skin temperature differences using palpation by manual physical therapists and lay individuals

David Levine[a], J. Randy Walker[a], Denis J. Marcellin-Little[b], Ron Goulet[c] and Hongyu Ru[d]

[a]Department of Physical Therapy, University of Tennessee at Chattanooga, Chattanooga, TN, USA; [b]Department of Veterinary Surgical and Radiological Sciences, University of California, Davis, CA, USA; [c]Department of Mechanical Engineering, University of Tennessee at Chattanooga, Chattanooga, TN, USA; [d]Department of Population Health and Pathobiology, College of Veterinary Medicine, North Carolina State University, Raleigh, NC, USA

ABSTRACT

Objectives: To evaluate the accuracy of detection of temperature differences among skin sites of lay individuals and manual physical therapists.

Methods: Forty-four manual physical therapists and 44 lay individuals were recruited. Subjects palpated two temperature-controlled surfaces that ranged in temperature between 30 and 35 °C and varied randomly by 1, 2, 3, 4, or 5 °C for 10 s. The subjects were then asked to identify the warmer pad.

Results: Accuracy increased with larger temperature differences. Accuracy of detection of 1 and 3 °C temperature differences was higher in manual physical therapists than lay individuals.

Discussion: Palpation can be used to accurately detecting temperature differences between sites and is more accurately performed by an experienced practitioner.

Level of Evidence: 3b

KEYWORDS
Skin temperature; palpation; manual therapy; physical therapist

Introduction

Palpation is a skilled examination tool involving physical touch to assess a variety of physical characteristics such as heart rate, bony deformity, tissue tenderness, tissue temperature, firmness, shape of living tissue [1]. Healthcare professionals use palpation for assessing various conditions. Accurate identification of anatomic landmarks improves as a result of medical training [2,3]. Skin palpation is used to determine skin texture, temperature, sweating differences, keratosis, pain, and induration [4]. Clinicians and lay individuals routinely palpate the skin to assess the presence of temperature changes. Clinicians use palpation to detect temperature changes resulting from inflammation associated with musculoskeletal disorders [5,6]. Overall, little is known about the accuracy of clinicians to identify differences in skin temperature. The ability of clinicians to detect temperature differences between skin sites using palpation was evaluated in one study using metal cylinders varying in temperature by 2, 4, or 6 °C [7]. In that study, participants correctly estimated temperature differences between cylinders only 10% of the time. The palpation methods used in that study may not have been representative of skin palpation. Assessing the ability of lay individuals and trained clinicians to assess temperature differences corresponding to the changes resulting from pathology is warranted.

The aims of the current study were to evaluate the accuracy of physical therapists trained in manual therapy (manual physical therapists) and lay individuals when identifying surfaces varying in temperature by 1, 2, 3, 4, or 5 °C. We hypothesized that manual physical therapists would more accurately detect temperature differences than lay individuals. We also hypothesized that the detection of larger temperature differences would be more accurate than the detection of smaller differences by both manual physical therapists and by lay individuals. To test these hypotheses we developed a skin surface simulation with two leather surfaces whose temperatures were independently controlled.

Methods

Subjects

A sample of convenience for both the lay and manual physical therapist groups signed informed consent before participating. Forty-four subjects in each group participated in this study. Participants included 31 male

CONTACT David Levine David-Levine@utc.edu

and 13 female manual physical therapists with a mean (±SD) age of 30.8 ± 6.6 years and 21 male and 23 female lay participants with a mean age of 32.7 ± 6.2 years. Inclusion criteria for the manual physical therapists included active licensure, having practiced for a minimum of one year, and currently utilizing a manual approach to therapy. Nine (20%) were board certified specialists in orthopaedics through the American Board of Physical Therapy Specialties. Laypersons were defined as individuals who had no prior history of palpation experience (e.g. healthcare practitioners, massage therapists). Exclusion criteria for both groups included any history of fracture or surgery of the hand or fingers, hypersensitivity disorders, sensory deficits, neuropathy, circulatory insufficiency, and diabetes mellitus. These criteria were self-reported.

Instrumentation

The device included two identical and independent deer skin leather chamois cloth covered temperature-controlled surfaces (Figure 1). Each control surface incorporated a thin film resistance heater sandwiched between 6-mm-thick, 150-mm-diameter aluminum disks, and a cooling fan. Surface temperatures were controlled using K-type thermocouple surface temperature sensors and programmable temperature controllers (Omega CN9000A Autotune Temperature Controller, Stamford, CT, 06907 USA) calibrated and accurate to 0.1 °C.

Procedure

Each testing session began with the subjects acclimating to the testing environment for 20 min. The rooms in which testing occurred were maintained at 20–22 °C. During this time, subjects were not allowed to hold anything in their dominant hand (e.g. hot or cold beverages). Subjects then were asked to palpate the two pads in any order. Subjects were allowed 10 s to alternately touch the two pads, palpating with the palmar surface of the dominant hand, before selecting the warmer pad. The machine operator was blinded to the responses of the subjects and the recorder and subjects were blinded to the temperature differences by a panel placed between the pads and the temperature control devices. A random table generator was used to determine the protocols, which consisted of randomly varying the temperatures of the pads from 1, 2, 3, 4, or 5 °C, spanning 30–35 °C. Each temperature variation was tested twice resulting, in 10 trials per subject for a total of 880 data points.

Statistical analyses were performed using statistical software (SAS, v. 9.4, SAS Institute Inc, Cary, NC). Probabilities of correctly identifying the warm pads were compared using a logistic regression model where repeated assessments, level of experience (manual physical therapist vs. lay individuals), temperature differences (1, 2, 3, 4, and 5°), and interaction between level of experience and temperature measurements were used as explanatory variables. *P* values < 0.05 were considered significant.

Results

Manual physical therapists and lay individuals correctly identified 1° differences among warm pads 78 and 62% of the time, respectively (Table 1). Manual physical therapists were 2.08 times more likely to correctly identify the warmer pad than lay individuals when pad temperatures differed by 1° ($p = 0.032$), 1.35 times more likely

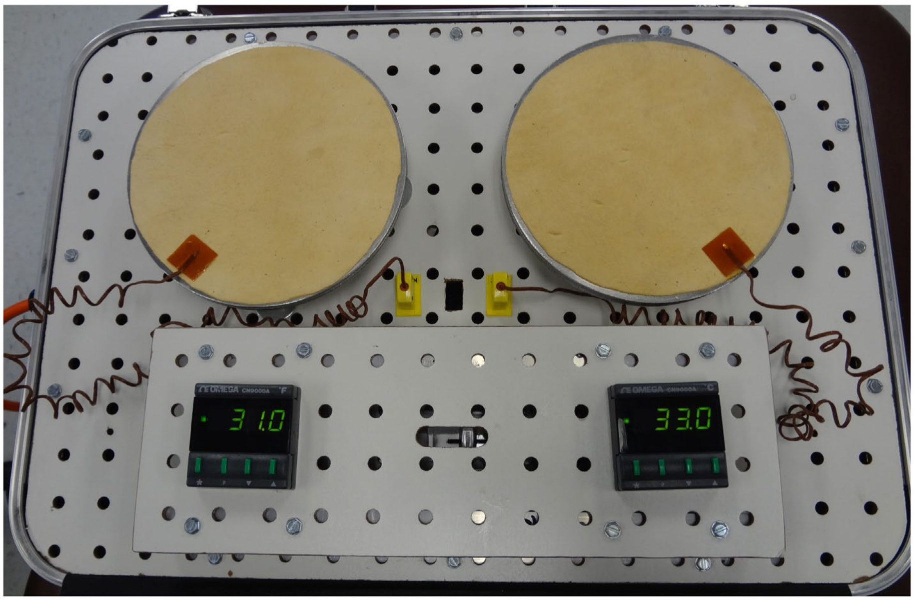

Figure 1. The temperature testing instrument included two 150-mm-diameter aluminum plates covered with deerskin leather chamois whose temperatures varied from 30 to 35 °C, creating gradients ranging from 1 to 5 °C.

Table 1. Comparisons of the accuracy of detection of temperature differences of 1, 2, 3, 4, or 5 °C between warm plates by manual physical therapists ($n = 44$) and lay individuals ($n = 44$).

Manual					
Physical therapists	1 °C	2 °C	3 °C	4 °C	5 °C
Accuracy*	0.78 ± 0.04	0.77 ± 0.05	0.98 ± 0.02	0.99 ± 0.01	0.98 ± 0.02
1 °C	–	0.93 $p = 0.857$†	12.5 $p < 0.001$	25.0 $p = 0.002$	12.5 $p < 0.001$
2 °C	0.93 $p = 0.259$	–	14.3 $p < 0.001$	25.0 $p < 0.001$	12.5 $p < 0.001$
3 °C	12.5 $p < 0.001$	14.3 $p < 0.001$	–	2.04 $p = 0.568$	1.00 $p = 1.000$
4 °C	25.0 $p = 0.002$	25.0 $p < 0.001$	2.04 $p = 0.568$	–	0.49 $p = 0.568$
5 °C	12.5 $p < 0.001$	12.5 $p < 0.001$	1.00 $p = 1.000$	0.49 $p = 0.568$	–
Lay individuals	1 °C	2 °C	3 °C	4 °C	5 °C
Accuracy	0.62 ± 0.05‡	0.71 ± 0.05	0.86 ± 0.04‡	0.92 ± 0.03	0.99 ± 0.01
1 °C	–	1.45 $p = 0.259$	3.57 $p < 0.001$	7.14 $p < 0.001$	50.0 $p < 0.001$
2 °C	1.45 $p = 0.259$	–	2.44 $p = 0.019$	5.00 $p < 0.001$	33.3 $p < 0.001$
3 °C	3.57 $p < 0.001$	2.44 $p = 0.019$	–	2.00 $p = 0.158$	14.3 $p = 0.009$
4 °C	7.14 $p < 0.001$	5.00 $p < 0.001$	2.00 $p = 0.158$	–	7.69 $p = 0.061$
5 °C	50.0 $p < 0.001$	33.3 $p < 0.001$	14.3 $p = 0.009$	7.69 $p = 0.061$	–

*Mean ± standard error.; †Odds ratio and corresponding P value. A 0.93 ratio for the comparison between 1 and 2° indicates that for manual physical therapists, the likelihood of correctly identifying the warmer pad was 7% lower when plate temperature differences were 2° compared to 1°. P values < 0.05 indicate significant differences between likelihoods of correctly identifying the warmer pad.
‡Accuracy differed for manual physical therapists compared to lay individuals.

when temperatures differed by 2° ($p = 0.390$), 7.69 times more likely when temperatures differed by 3° ($p = 0.009$), 7.69 times more likely when temperatures differed by 4° ($p = 0.061$), and 2.03 times less likely when temperatures differed by 5° ($p = 0.567$).

Manual physical therapists were more likely to correctly identify 3, 4, or 5° differences between plates compared to 1 and 2° differences (Table 1). Similarly, lay individuals were more likely to correctly identify 3, 4, or 5° differences between plates compared to 1 and 2° differences and were also more likely to correctly identify 5° differences compared to 3° differences.

Discussion

Palpation is an integral part of the physical examination of soft tissues. Tissue changes, particularly inflammation, lead to changes in skin temperature [8–10]. The results of the current study indicate that manual physical therapists and laypersons can detect temperature differences as small as 1–2 °C, making palpation a valid tool when screening for pathology involving increased tissue temperature.

This study compared the likelihood of correctly identifying a warmer plate, as a simulation of the ability to identify areas of increased skin temperature. The likelihoods of correctly identifying a warmer plate in manual physical therapists and lay individuals were compared and likelihoods for 1, 2, 3, 4, and 5 °C differences were also compared. The warm plates surfaces simulated human skin. The device was designed for the study. Temperatures ranges were selected based on anticipated skin temperature. Skin temperature decreases with more distal locations along limbs. In one study, skin temperature over paraspinal muscles ranged from 30 to 35.4 °C [11]. The forearm temperature ranged from 32 to 33 °C in one report [12]. A temperature of 31.3 °C was reported for the middle finger [13]. The reported mean knee temperature was 29.5 °C in one study [14]. Therefore, a protocol ranging from 30 to 35 °C was created to account for skin temperature variations.

The temperature differences of 1–5° tested in this study correspond to the temperature changes resulting from pathology. Mean increases in focal tissue temperature up to 4.6 °C have been reported in studies describing patients with wounds, infections, or arthopathies. One study reported mean skin temperatures increases of 3.1 °C in patients with neuropathic ulcers and 4.6 °C in patients with neuropathic arthropathies [15]. Mild skin temperature elevation over joints with osteoarthritis has been reported in several studies. Mean skin temperature elevation over osteoarthritic knees was 0.6 °C in two reports and 0.1 °C in another [10,16,17]. A mild increase in mean skin temperature (0.5 °C) was also reported in patients with inflamed ankles because of rheumatoid arthritis [8].

Skin temperature increases and remains elevated for several months after total knee replacement. In one report, a mean temperature increase of approximately 2.5 °C was reported, peaking at 7 days after surgery and subsiding slowly over time [10]. Differential temperatures between operated and control knees were inversely correlated with disability scores. These differences subsided slowly but were still detected one year after surgery (0.9 °C difference). Another total knee replacement study reported a peak mean temperature elevation of 2.9 °C seven days after surgery that subsided slowly over time [17]. After one year, the difference was 0.3 °C. The difference was no longer detectable after two years. Focal infection also results in skin temperature elevation. In one study, the mean skin temperature of patients with infected total knee implants was 1.6 °C warmer than non-infected total knee implants with aseptic loosening and was 1.9 °C warmer than normal skin temperature [9]. In another report, skin temperature adjacent to infected venous ulcers was 2.2 °C warmer than non-infected venous ulcers and 2.4 °C warmer than normal skin temperature [18].

Conversely, a mean decrease in focal skin temperatures of 6.2 °C was reported in the volar surface of the hand of patients with Raynaud's phenomenon [19]. A mean decrease of skin temperature of up to 3.5 °C was reported in the feet of patients with complex regional pain syndrome [20]. A mean decrease of 1.3 °C was reported in the foot of patients with polyneuropathy [21].

We accepted our hypothesis that the rate of accurate detection by manual physical therapists and by lay individuals increased when temperature differences between plates increased. Lay individuals accurately detected the warmer plate only two thirds of the time when differences were 1 or 2 °C, accurately detected the warmer plate approximately 90% of the time when the temperature difference was 4 °C, and >95% when the difference was 5 °C. Manual physical therapists accurately detected the warmer plate > three quarters of the time when differences were 1 or 2 °C and detected differences of ≥3 °C with an accuracy >95%. We accepted our hypothesis that manual physical therapists were more accurate than lay individuals for smaller gradients (1 and 3°). These differences disappeared with larger gradients, as the accuracy of lay individuals approached 100%. The source of the increased accuracy observed in manual physical therapists compared to lay individuals is not known. Increased accuracy could result from differences in palpation technique or in the cognitive processing of perceived temperatures differences. Palpation technique likely influences thermal perception. Thermal perception differs based on the area of contact and on contact mechanics. Low-threshold thermal nociception is greater on the forearm than on fingers or on palmar surface of the hand [22]. Also, touch with movement inhibits thermal and nociceptive sensation because sensory interactions alter perception [22].

The detection of hyperthermia (fever) using skin palpation has been reviewed [23]. Maternal touch was more useful to exclude the presence of fever than to rule in fever. In one study, mothers overestimated fever in their children (sensitivity was 97.3% and specificity was 19.2%) but clinically trained individuals did not (sensitivity was 82.2% and specificity was 67.8%) [24].

This project had limitations. Skin was simulated using deerskin leather. Potential differences between males and females were not assessed. Gender differences in thermal nociception have been reported [25]. In the current study, the influence of gender on accuracy of detection was not evaluated due to the relatively small sample size. Also, additional research could investigate the mechanisms leading to improvement in detection of temperature differences.

We concluded that palpation can accurately detect temperature differences between skin sites. Accuracy increases with larger temperature differences. Manual physical therapists are more accurate than lay individuals.

Disclosure statement

The authors declare no conflicts of interest for this study.

Notes on contributors

David Levine, PT, PhD, DPT, OCS, Cert. DN, is a professor and the Walter M. Cline Chair of Excellence in Physical Therapy at the University of Tennessee at Chattanooga. Levine's fields of interest include: physical therapy and rehabilitation, orthopaedics, dry needling, and motion analysis.

J. Randy Walker, PT, PhD, DPT, CMP, CMTPT, is a professor and former department head of the Department of Physical Therapy at the University of Tennessee at Chattanooga. Walker's fields of interest include: manual therapy, dry needling, and program accreditation.

Denis J. Marcellin-Little, DEDV, is a professor of Orthopedic Surgery at the University of California, Davis. Marcellin-Little's fields of interest include: the management of orthopedic problems, particularly joint disease and limb deformities, limb sparing and the design, fabrication, and implantation of custom orthopedic implants.

Ron Goulet, PhD, PE, is an associate professor of Mechanical Engineering at The University of Tennessee at Chattanooga. Goulet's fields of interest include: biomechanics, fracture mechanics, and failure analysis.

Hongyu Ru, PhD, is a clinical assistant professor of Biostatistics at North Carolina State University.

ORCID

Denis J. Marcellin-Little http://orcid.org/0000-0001-6596-5928

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