

Roller massage: is the numeric pain rating scale a reliable measurement and can it direct individuals with no experience to a specific roller density?

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This investigation measured the reliability of the numeric pain rating scale (NPRS) for roller massage (RM) over two sessions and compared it to pressure pain threshold (PPT) during a third session. Twenty-five subjects participated. Session one, subjects rolled on 3 different rollers and filled out the NPRS for each roller then chose their preferred roller. Session two, subjects repeated the testing blind-folded to eliminate visual biases. Session three, subjects repeated testing but were measured with PPT. For the NPRS, there was poor to moderate reliability for the soft roller (ICC=0.60) and good reliability for the moderate (ICC=0.82) and hard density (ICC= 0.90) rollers. For preferred roller, there

Cette étude visait à mesurer la fiabilité de l'échelle numérique d'évaluation de la douleur (ÉNÉD) utilisée pendant deux séances d'automassage avec rouleau par rapport au seuil de perception de la douleur à la pression (SDP). Vingt-cinq sujets ont participé à l'étude. Durant la première séance, les sujets se sont massés à l'aide de trois rouleaux différents; pour chaque rouleau, ils ont utilisé l'ÉNÉD, puis ils ont indiqué leur rouleau préféré. Durant la deuxième séance, les sujets ont refait le test les yeux bandés pour éliminer les biais visuels. Durant la troisième séance, les sujets ont refait le test, mais cette fois-ci ils ont comparé leur douleur par rapport au SDP. En ce qui concerne l'ÉNÉD, la fiabilité variait de faible à moyenne pour le rouleau mou (CCI = 0,60) et était bonne pour le rouleau de fermeté moyenne (CCI = 0,82) et le rouleau très ferme (CCI = 0,90). Pour ce qui est du rouleau préféré, aucune différence significative n'a été observée entre

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was no significant difference between sessions ($t(24) = .00, p = 1.00$). For NPRS and PPT, there was a fair relationship for all rollers ($Rho = 0.34-0.49, p = 0.11-0.28$). The NPRS appears to be a reliable measure and may help direct individuals to a specific roller. The NPRS and PPT should be used independently.

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KEY WORDS: massage, roller, muscle soreness, myofascial, perceived pain, recovery

Introduction

Roller massage (RM) with a foam roller or other device is a common myofascial intervention. Rehabilitation professionals may utilize different types of rollers within their setting for specific patients. Many types of rollers are also available to consumers with different surface textures, shapes, and densities. There has been growing interest among researchers regarding the effects of RM on pain perception (e.g. numeric pain rating scale-NPRS) and pressure pain threshold (PPT) using algometry. Pain is a complex multidimensional process involving the central nervous system and other systems of the body.^{1,2} Several studies have suggested that RM can modulate pain perception (e.g. delayed onset of muscle soreness) after exercise^{3-9,12} and increase PPT in the ipsilateral^{8,10-13} and contra-lateral limb^{8,10-13}. Researchers have postulated that the mechanical pressure on the tissues from RM may modulate pain through stimulation of cutaneous receptors¹⁴, mechanoreceptors¹⁵, afferent central nociceptive pathways^{11,14} and descending anti-nociceptive pathways (diffuse noxious inhibitory control)^{14,16}.

Several investigations have reported that the myofascial system may respond in a similar manner to low, moderate, and high RM pressure but higher pressure may have a greater effect.^{14,15,17} Researchers have used pre-set NPRS scores to represent the spectrum of pressure or pain: light (5/10), moderate (7/10), and hard (9/10).¹⁷ Grabow *et al.*¹⁷ found that short bouts of RM (3 sets of 60 seconds) on the quadriceps at a low ($3.9/10 \pm 0.64$ NPRS), moderate ($6.2/10 \pm 0.64$ NPRS) and high pressure ($8.2/10 \pm 0.44$ NPRS) produced similar post-intervention increases in range of motion (ROM) and did not impair muscle

les séances ($t(24) = 0,00, p = 1,00$). Pour l'ENÉD et le SDP, le rapport était juste pour tous les rouleaux ($Rho = 0,34 - 0,49, p = 0,11 - 0,28$). L'ENÉD semble être un instrument de mesure fiable pouvant aider les personnes à choisir un rouleau particulier. L'ENÉD et le SDP devraient être utilisés de façon séparée.

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strength or jump performance in healthy subjects. Young *et al.*¹⁵ showed that short bouts of RM (three sets of 30 seconds) at low, moderate and high pressures diminished spinal excitability measured by the Hoffman or H-reflex in the soleus muscle in healthy individuals. Using descriptor words to measure pressure, the higher roller pressure significantly decreased the H-reflex (58%) compared to moderate (43%) and low pressure (19%).¹⁵ Cavanaugh *et al.*¹¹ also showed that short bouts of RM (three sets of 30 seconds) at a 7/10 NPRS pressure diminished evoked pain and prolonged muscle torque development in healthy males. Thus, higher RM pressure (NPRS $\geq 7/10$) may have a greater effect on increasing PPT in subjects than moderate or light pressure.^{14,15}

It is important to note that these studies used an examiner or mechanical device to apply the RM pressure based upon a predetermined NPRS score and subjects reported their pain level during treatment in order to maintain that level of applied pressure.^{11,14,15,17} Researchers have also used pressure algometry to measure the post-treatment effects of RM on PPT in prior studies.^{12,18,19} Clinicians must consider that these research measures may not be practical in all clinical settings. Furthermore, patients participating in a RM session may lay on a roller and apply pressure with their bodyweight making it difficult to apply a graded pressure that is based upon an NPRS score.

An alternative may be for patients to roll on different density type rollers and choose one that matches a desired NPRS score. In a clinic setting, the clinician may have different types of rollers available or may be limited to a specific type of roller for the patient to use. Clinician may also prescribe a certain roller based upon their clinical



Figure 1.

Types of rollers: soft (silver), moderate (orange), hard (black)



Figure 2.

JTECH algometer

experience since no clear guidelines exist.²⁰⁻²² For individuals, they may choose a specific roller based upon personal preferences such as: color, brand name, roller shape or style, texture, and cost.

The use of the NPRS to help direct patients to a specific density type roller may be more practical in the clinical setting. This may also have implications in the presence of injury or existing pain, a patient's perceived pain may be variable and influence their tolerance or preference for a certain density roller. Knowing this relationship may help clinicians to better match a roller to the patient or to utilize different rollers for certain conditions. The purpose of this investigation was to measure the reliability of the NPRS for different density type rollers over two sessions and compare it to PPT algometry. Through this research, we sought to answer the following questions: (1) Is the NPRS a reliable measure for different density type rollers? (2) Does measured pain perception after RM influence an individual's preference for a specific roller? (3) Does the NPRS and PPT offer interchangeable measures of pain perception with respect to RM?

Methods

Subjects

Twenty-five recreationally active adults (M=14, F=11) (age= 24.5 ± 3.4 years, height= 167.5 ± 9.3 cm; body mass= 65.4 ± 10.4 kg; body mass index= 23.2 ± 2.2) were

recruited via convenience sampling (e.g. flyers). Subjects included in the study reported participating in recreational fitness activities (e.g. walking) with no prior experience using RM. Exclusion criteria included the presence of any musculoskeletal, systemic, or metabolic disease that would affect lower extremity joint range of motion or tolerance to testing and the inability to avoid medications that may affect testing. This study was approved by the Institutional Review Board at California State University Dominguez Hills, Carson, CA, USA (#18-024).

Rollers and Instruments

The three rollers used in this study were manufactured by TriggerPoint™ (TriggerPoint, a division of Implus, LLC, 5321 Industrial Oaks Blvd., Austin, Texas 78735, USA) and all had the same multilevel GRID surface pattern and diameter (14 cm) which allowed for a direct comparison. The difference between the three rollers was the density. The soft density CORE roller (silver) was constructed of solid EVA foam, the moderate density GRID roller (orange) had a hard, hollow core that was wrapped in moderately firm EVA foam, and the hard density GRID X roller (black) had a hard, hollow core that was wrapped in very firm EVA foam (Figure 1).

The JTECH (Midvale, UT) Tracker Freedom® wireless algometer (Figure 2) was used with the accompanying Tracker 5® Windows® based software to measure PPT. The manufacturer reports an accuracy error of \pm

0.5% (.05kg/cm²) for this technology.²³ Algometry is a valid and reliable tool for measuring pressure pain thresholds.^{14,24-26} This instrument has also been used in prior foam roll research.^{12,18,19}

Outcome Measures

Two outcome measures were used for this investigation. First, the NPRS was used to measure a subject's perceived pain level. The NPRS is a widely used patient reported outcome scale.²⁷⁻²⁹ The ordinal 11-point NPRS (0-no pain, 10-most intense pain) is the most commonly used version which has good test-retest reliability ($r=.79-.96$) in individuals with chronic pain and musculoskeletal pathology.^{27,28,30-32} The NPRS has been used in prior foam roll research.^{3,6,8,9,33,34}

Second, the pressure algometer was used to measure PPT and considered the gold standard for this investigation. The dominant (kicking leg) quadriceps group was tested with the subject in the relaxed standing position (two measurements).^{5,35,36} The 1.0-cm² probe of the algometer was placed into the midline of the quadriceps muscle (rectus femoris) midway between the iliac crest and superior border of the patella. The graded force was applied at a constant rate of 50-60 kilopascals per second (kPa/sec) until the subject verbally reported the presence of pain.^{5,35,36} This measure has been used in prior foam roll research.^{12,18,19}

Pilot Study

Prior to data collection, a two-session pilot training was conducted to establish intrarater reliability for algometry. The primary investigator took all the measurements. The primary investigator is a licensed physical therapist with over 13 years of experience and board certified in orthopaedics. Ten independent subjects were recruited and tested for this portion of the study. The intrarater reliability was calculated using the Intraclass Correlation Coefficient (ICC model 3, k). There was good intrarater reliability for pressure algometry (ICC= 0.94; 95% CI 0.61-0.96).

Procedures

All eligible participants were given an IRB approved consent form to read and sign before testing. Participants then completed a questionnaire to provide demographic information. All participants were blinded from the results and other participants enrolled in the study. The three foam

rollers used in the study were assigned a number and randomized for all testing sessions using a random number generator. Testing was conducted between the hours of 10:00 AM and 12:00 PM and subjects were instructed to refrain from any strenuous activity three hours prior to testing and from taking any medication or supplements that would interfere with testing. All subjects underwent three sessions of testing with a 48-hour period between sessions.

Prior to each testing session, the primary investigator explained and demonstrated the testing procedures to each subject and answered any questions. For session one (NPRS), the subjects assumed the plank position, put the roller under their dominant leg (e.g. kicking leg) quadriceps muscle, and rolled back and forth using their preferred technique. The subjects rolled on each roller for one minute and then immediately documented their perceived level of pain using the NPRS after rolling. Subjects rested for one minute between each roller. The investigator was present to help change rollers and time each trial and rest period but did not provide any feedback to the subject. Upon completion of testing, the subjects then chose their preferred numbered roller based upon the level of discomfort they felt with all three rollers. The subjects could see the rollers but were not allowed to feel or hold them. This procedure was meant to mimic a possible situation where individuals may try different rollers, measure their perceived pain level, and choose their preferred roller.

For session two (NPRS control), the subjects replicated the first session procedures, however, were blind-folded by wearing an eye mask during testing. Subjects assumed the plank position and were assisted by the investigator. The investigator helped change rollers, place them under the dominant leg, timed each trial, and rest period. Subjects did not see the rollers and only lifted the mask to document their NPRS scores. Upon completion of testing, the subjects chose the preferred roller based upon the level of discomfort they felt with all three rollers. The subjects could not see the rollers or feel or hold them after testing. Session two was considered the control. Blindfolding of subjects was meant to control for visual preferences of seeing the rollers which could influence the grading of a subject's pain perception and choice of preferred roller.

For session three (PPT), Subjects followed the testing procedures in session one (non-blindfolded) and were assisted by a second investigator. The NPRS was replaced

Table 1.
Subject demographics

	Age (years)	Height (cm)	Mass (kg)	BMI (kg/m ²)
Subjects (N=25)	24.5 ± 3.4 years	167.5 ± 9.3	65.4 ± 10.4	23.2 ± 2.2
Data reported as mean ± SD; m, meters; BMI=body mass index; kg=kilograms				

with PPT using pressure algometry. The primary investigator took posttest PPT measures for each roller and was blinded to which roller was used. The subjects and second investigator were blinded to all measures. Upon completion of testing, the subjects then chose their preferred numbered roller based upon the level of discomfort they felt with all three rollers. The subjects could see the rollers but were not allowed to feel or hold them after testing.

Statistical analysis

Statistical analysis was performed using SPSS version 24.0 (IBM SPSS, Chicago, IL, USA). Subject descriptive data was calculated and reported as the mean and standard deviation (SD) for age, height, body mass, and body mass index (BMI). The Intraclass Correlation Coefficient (ICC model 3, k) was used to calculate reliability between sessions for the NPRS. The ICC is a widely used reliability index for test-retest reliability.³⁷ The ICC has been used in prior research to measure the reliability of the NPRS among individuals with myofascial pain and fibromyalgia.² The criteria for evaluating the reliability coefficient was as follows: <.75 = poor to moderate, ≥.75 = good reliability.³⁸ Differences between sessions was calculated using the t-test.³⁸

Correlations between the NPRS and PPT were calculated using the Spearman Rho (Rho) correlation coefficient (95% limits of agreement). The Spearman Rho correlation, a non-parametric statistic, was used to measure the correlation between the ordinal NPRS and ratio pressure pain threshold measurements.³⁸ The Spearman Rho correlation has been used in prior research to measure the correlation between the NPRS and PPT among individuals with myofascial pain and fibromyalgia.^{1,2} The criteria for the evaluating the correlation coefficient was as follows: .00-.25 = little or no relationship, .25-.49 = fair relationship, .50-.75 = moderate to good relationship, and

values greater than .75 = excellent relationship.³⁸ Statistical significance was considered $p < .05$ for all measures.

Results

Twenty-five subjects completed the study. There were no adverse events or subject attrition during data collection. Patient demographic data is presented in Table 1. For NPRS reliability (session 1 and 2), there was poor to moderate reliability for the soft-roller (ICC= 0.60; 95% CI 0.18-0.87), good reliability for the moderate density roller (ICC= 0.82; 95% CI 0.46-0.94), and good reliability for the hard density roller (ICC= 0.90; 95% CI 0.69-0.96). There was no significant difference between sessions for the soft ($t(24) = -1.66, p = 0.12$), moderate ($t(24) = .48, p = 0.64$), and hard ($t(24) = .30, p = .30$) density rollers. The average NPRS score for both sessions that correspond to each density were as follows: soft density 3.9/10, moderate density 5.3/10, and hard density 6.3/10. For preferred roller (sessions one and two), there was no significant difference between sessions for roller preference ($t(24) = 0.00, p = 1.00$). Sixty percent of subjects 60% (15/25) chose the same roller (hard 7/15, medium 5/15, light 3/15) and 40% (10/25) chose a different roller.

When correlating NPRS and PPT scores (sessions one and three), there was a fair relationship for the soft (Rho = 0.34, 95% CI = 0.11-0.79, $p = 0.28$), moderate (Rho = 0.49, 95% CI = 0.12-0.85, $p = 0.11$), and hard density (Rho = 0.41, 95% CI = 0.19-0.81, $p = 0.18$) rollers (Table 2). There was also a significant difference between the NPRS and PPT for the soft ($t(24) = -17.24, p < 0.001$), moderate ($t(24) = -20.27, p < 0.001$), and hard ($t(24) = -14.75, p < 0.001$) density rollers.

Discussion

Several studies have used measured pain perception to control pressure applied during RM and to measure the post-treatment effects. These studies have either used

Table 2.
Correlation between NPRS and PPT (session 1 and session 3)

Roller Density	Spearman Rho (Rho)	95% CI	P-Value
Hard Density	.41	.19-.81	.18
Moderate Density	.49	.12-.85	.11
Soft Density	.34	.51-.79	.28

NPRS= numeric pain rating scale; PPT= pressure pain threshold, p-value significant at $p < .05$

examiner or devices to apply a predetermined pressure based upon a NPRS score.^{11,14,15,17} These methods may be good for research but may not be practical in the clinical setting. This investigation examined a more practical approach to measuring RM pressure and roller preference by having subjects roll on different density rollers (soft, moderate, hard) and document their posttest discomfort with the NPRS. Currently, there is no consensus on the optimal way to help individuals choose a roller. Clinicians may recommend a roller based upon their personal preference and individuals may also choose a roller using similar rationale. This study attempted to answer three clinical questions that are discussed below.

Is the NPRS a reliable measure for different density type rollers?

Subjects underwent two sessions of testing: non-blind folded and blind-folded (control). The blind-folded session helped eliminate any visual biases that would influence the subjects grading of their pain perception with each density roller. The results showed poor to moderate reliability for the soft (ICC= 0.60), good reliability for the moderate density roller (ICC= 0.82), and good reliability for the hard density roller (ICC= 0.90). These findings suggest that the NPRS may be used as a repeated measure and to direct individuals to a specific roller.

The average NPRS score for both sessions that correspond to each density were as follows: soft density 3.9/10, moderate density 5.3/10, and hard density 6.3/10. The average NPRS score found in this investigation are similar to the scores found in the Grabow *et al.* study¹⁷ and support the theory that subjects may respond more to higher pressure levels than lighter pressure due to higher levels of perceived discomfort¹⁵. Higher pressure or dis-

comfort may produce a stronger stimulus which effects a variety of mechanoreceptors and nociceptors, changes in neuromuscular stretch tolerance, or activation of the ascending and/or descending pain modulation systems.^{15,17} Thus, harder density rollers may produce higher pressure to the myofascia resulting in an elevated level of perceived discomfort. This theory still needs to be confirmed with further research.

Does measured pain perception during rolling influence an individual's preference for a specific roller?

This investigation explored how measured pain perception influences a subject's choice for a specific roller. The results revealed no significant difference between sessions for roller preference ($p=1.00$). Sixty percent of subjects (15/25) chose the same roller and 40% (10/25) chose a different roller. The variability in subject's choice of rollers may be attributed to the differences between session one and session two (blind-folded). During session two, subjects were blind-folded which prevented them from seeing the roller and required them to grade their discomfort based upon the pressure felt with each roller. This controlled for possible visual biases and may have provided a purer measure of a subject's pain perception. These results were not expected when considering the consistency in NPRS scores for sessions one and two. Subjects would choose a similar roller each session.

Does the NPRS and PPT offer interchangeable measures of pain perception with respect to RM?

The NPRS is a widely used subjective pain measure that has good test-retest reliability ($r=.79-.96$).^{27,28,30-32} The NPRS has been used in RM research to measure the post-treat-

ment effects of RM on pain perception^{3,6,8,9,33,34} and to grade the pressure applied during RM testing by following a predetermined pain level^{11,15,17,39}. Pressure algometry has also been used in RM research to measure PPT^{5,12,14,19,36,40} and is considered the gold standard in pain research¹. Due to the widespread use of both measures in research, this investigation sought to examine the interchangeability of the measures for clinical practice. The results only showed a fair relationship between the two measures for all three densities challenging the interchangeability of the measures. It is recommended that each measure be used independently to ensure measurement accuracy, however the choice of a preferred roller is multifactorial. It appears that the NPRS may be more practical in the clinical setting since it's easier to administer.

Limitations

There are specific limitations to the investigation that need to be discussed. First, this investigation tested healthy untrained subjects which limits the generalizability of the results to this population. Second, the three foam rollers used had the same multilevel GRID pattern surface and diameter which allowed for a direct comparison. Other foam rollers with different surface patterns, diameters, and densities may have produced different results. Third, the immediate posttest effects of each foam roll intervention were studied with the dominant quadriceps muscle only. Rolling on other muscle groups may have produced different results. Fourth, the subjects used their own preferred method of rolling. Other rolling techniques may have produced different results.

Clinical Relevance and Future Research

The translation of RM research to clinicians can be challenging since the methods used in the studies may not be practical in all settings. This investigation attempted to examine the reliability of the NPRS for different roller densities and if it can direct patients to a specific roller. The results suggest several findings that clinicians may be able to use in most clinical settings. First, the NPRS appears to be a repeatable measure of perceived pain and may help the clinician to direct patient to a specific roller. The NPRS is easy to administer and can allow patients to progress through different density rollers based upon a preset score. This may be clinically relevant in the presence of injury or pain, since pain is very subject-

ive and a multidimensional process involving the central nervous system and other systems of the body.^{1,2} Second, the NPRS and PPT with pressure algometry may not be interchangeable measures. The results from this investigation suggest that each measure should be independent to ensure measurement accuracy.

There are still many unknown questions regarding the neurophysiological effects of RM and the optimal program for individuals. Future research should study the short and long-term efficacy of RM on perceived pain in individuals with specific injuries or musculoskeletal conditions. The current research is variable and has focused on the short-term effects of RM in healthy individuals.²⁰

Conclusion

Currently, there is no consensus on the optimal method of progressing patients through the various density type rollers. This may be an issue for patients who are experiencing pain and may need a method of safely progressing through the different density rollers. The NPRS may be a reliable measure to help guide patients through the different rollers and provide a way of documenting a patient's tolerance and progress with RM. The NPRS appears to have more utility than other measures, such as PPT, and should not be interchanged to ensure measurement accuracy.

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