Reproducibility and reliability of pressure algometry: are digital and analogue devices comparable?

Reprodutibilidade e confiabilidade da algometria de pressão: os algômetros digital e analógico são comparáveis?

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ABSTRACT

BACKGROUND AND OBJECTIVES: Digital and analogue algometry have been widely employed in clinical studies, but a recent investigation observed a systematic error between devices, which may hinder comparison of data from different studies. The objective of this study was to evaluate the reproducibility and reliability of analogue and digital algometers.

METHODS: This was an observational transversal study involving 40 healthy adults. They had preserved cognitive capacity and no chronic or acute pain. Participants were submitted to pressure pain threshold (PPT) assessment by two different algometers, 15 minutes apart: a digital device (Wagner Pain Test FPX) and an analogue one (Wagner Force Dial). Data collection involved 2 evaluators and occurred once a week. The muscles evaluated were teres major, upper trapezius, elevator scapulae, supraspinatus, infraspinatus, pectoralis, middle gluteus, paraspinal and deltoid.

RESULTS: Reliability between the measurements taken by the same evaluator (intra-rater reliability) or with the same device (inter-rater reliability) on different days was analyzed using the Intraclass Correlation Coefficient (ICC). When comparing the intra-rater reliability (evaluator 1, weeks 1 and 3), good or excellent reproducibility was observed in most of the sites, with both analogue and digital algometers, with statistical significance. The inter-device reliability (digital and analogue algometers) showed a significant and excellent correlation ($r > 0.75$) in all evaluated sites for both evaluators. The analysis of inter-rater reliability (2 different evaluators) for the digital algometer revealed good or excellent significant correlation in almost all sites, except for the left pectoralis major. For the analogue algometer, all evaluated sites exhibited good or excellent correlation with statistical significance.

CONCLUSION: The data highlight that digital and analogue algometry have good intra-rater reliability (reproducibility), inter-device reliability and inter-rater reliability in a sample of healthy young individuals.

Keywords: Evaluation study, Pain, Pain threshold, Reproducibility of results.

RESUMO

JUSTIFICATIVA E OBJETIVOS: A algometria digital e a analógica têm sido amplamente utilizadas em estudos clínicos, mas uma investigação recente observou um erro sistemático entre os dispositivos, o que pode dificultar a comparação de dados de diferentes estudos. O objetivo deste estudo foi avaliar a reprodutibilidade e a confiabilidade de algômetros analógicos e digitais.

MÉTODOS: Este foi um estudo transversal observacional que envolveu 40 estudantes saudáveis. Eles tinham capacidade cognitiva preservada e não apresentavam dor crônica ou aguda. Os participantes foram submetidos à avaliação do limiar de tolerância à dor por pressão (LTDP) por dois algômetros diferentes, com 15 minutos de intervalo: um dispositivo digital (*Wagner Pain Test* FPX) e um analógico (*Wagner Force Dial*). A coleta de dados envolveu dois avaliadores e ocorreu uma vez por semana. Os músculos avaliados foram o redondo maior, o trapézio superior, o levantador da escápula, o supraespinhal, o infraespinhal, o peitoral, o glúteo médio, o paraespinhal e o deltoide.

RESULTADOS: A confiabilidade entre as medidas realizadas pelo mesmo avaliador (confiabilidade intra-avaliador) ou com o mesmo aparelho (confiabilidade interavaliador), em dias diferentes, foi analisada por meio do Coeficiente de Correlação Intraclasse (CCI). Ao comparar a confiabilidade intra-avaliador (avaliador 1, semanas 1 e 3), observou-se reprodutibilidade boa

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HIGHLIGHTS

- Digital and analogue algometry have good intra-rater reliability (reproducibility)
- Digital and analogue algometry presented good inter-device reliability
- Digital and analogue algometry exhibited good inter-rater reliability

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ou excelente na maioria dos sítios, tanto com algômetro analógico quanto digital, com significância estatística. A confiabilidade interdispositivos (algômetro digital e analógico) apresentou correlação significativa e excelente (r > 0,75) em todos os locais avaliados e para ambos os avaliadores. A análise da confiabilidade interavaliadores (2 avaliadores diferentes) para o algômetro digital revelou correlação significativa boa ou excelente em quase todos os locais, exceto no peitoral maior esquerdo. Para o algômetro analógico, todos os locais avaliados apresentaram correlação boa ou excelente com significância estatística.

CONCLUSÃO: Os dados destacaram que a algometria digital e a analógica apresentaram boa confiabilidade intra-avaliador (reprodutibilidade), confiabilidade entre dispositivos e confiabilidade entre avaliadores em uma amostra de jovens saudáveis.

Descritores: Estudos de avaliação, Dor, Limiar da dor, Reprodutibilidade dos testes.

INTRODUCTION

The evaluation of sensitivity to pain is and objective method to quantify the discomfort caused by a painful stimulus. Pressure algometry has been employed to this end as opposed to the palpation of the regions of interest[1]. It offers valuable insights on the nociceptive function and may assist early diagnosis and personalization of the treatment[2].

Since the study[3] that validated this technique and provided standard values for healthy individuals, algometry has been widely employed in various clinicals settings: low back pain[4], knee osteoarthritis[5], fibromyalgia[6], neck pain[7] and temporomandibular joint disorders[8], among others. From that time on, devices (pressure gauges attached to a 1 cm^2 rubber plunger) have gradually changed from analogue to digital monitors, both still co-existing and sharing preferences among researchers.

Some studies have evaluated reproducibility[9] and reliability[1,10] of algometry, but a recent study observed a systematic error between digital and analogue devices: pressure pain thresholds (PPTs) of middle-aged subjects seemed to be higher when evaluated by the analogue device[11]. This may discourage the use of different devices in large trials, and hinder comparisons among data from studies with analogue and digital devices.

This type of quantitative sensory assessment is widely used in clinical practice and research in both patients and healthy individuals. The establishment of normative parameters in healthy populations is useful to provide references even for studies involving patients[12]. This has been exemplified by a recent study that evaluated the pressure pain threshold of healthy individuals to establish values for comparison to groups of patients with pain, allowing the identification of potential conditions of hypo- or hyperalgesia.

Algometry has already been studied in healthy individuals[13], but as far as is known, no study has compared reproducibility and reliability of different devices in healthy individuals. Thus, the aim of the present study was to contribute to the discussion on reproducibility and reliability of analogue and digital algometers, by providing data on healthy adult subjects.

METHODS

This was an observational transversal study involving 40 healthy university students aged 18-35 years old. The protocol followed national and international ethics regulations and was reviewed and approved by the local Ethics Committee (under opinion number 1.221.945). Volunteers signed the Free and Informed Consent Term (FICT) prior to their participation in this study. They had preserved cognitive capacity and no chronic of infectious diseases. Exclusion criteria included the use of drugs for pain relief (anti-inflammatory or analgesic) in the 3 previous days from the assessments, surgery or traumas in the last 6 months, fever (viral or bacterial infection), severe posture disfunctions, presence of abdominal cramps, renal colic, pregnancy, pain or discomfort in the spine (pain perception>4 in a visual analogue scale ranging from 0 to 10).

Participants were randomly submitted to PPT assessment by two different algometers, 15 minutes apart: a digital device (Wagner Pain Test FPX, Greenwich CT, USA) and an analogue one (Wagner Force Dial, Greenwich CT, USA). Data collection involved 2 experienced evaluators, and occurred once a week, as shown in figure 1.

The devices contain a 1 cm^2 diameter rubber end. Pressure was applied at a constant rate of 1kg/s until the point at which the participant reported pain or discomfort. Readings were expressed in kgf. During the assessment, volunteers were instructed to say "stop" as soon as the pressure sensation transitioned from unpleasant to painful. The test was stopped as soon as the volunteer indicated the onset of pain, and the final amount of force applied was registered. Areas in the following muscles were evaluated: teres major, upper trapezius, levator scapulae, supraspinatus, infraspi-

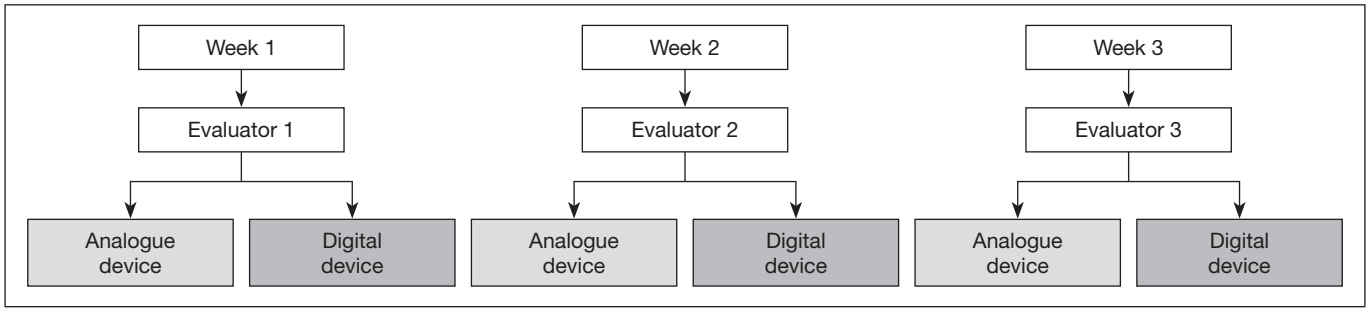

Figure 1. Scheme of data collection

natus, pectoralis, middle gluteus, paraspinal muscles (at L4 level, and at 2cm and 4cm from the medial line), and deltoid muscle. These regions have been previously described and assessed by a study[3].

Individuals were asked to assume the positions of prone, supine, and seated. Evaluations occurred in afternoons in a reserved environment within a university clinic.

This method was chosen because it has been widely employed by other studies since the 1980's[3], as well as in more recent studies conducted with healthy individuals[15-18].

Statistical analysis

Data were analyzed with descriptive statistics using the software SPSS v.27 for Windows. Reliability between the measurements taken by the same evaluator (intra-rater reliability) or with the same device (inter-rater reliability) on different days was analyzed using the Intraclass Correlation Coefficient (ICC) and categorized as follows: <0.4 - poor; 0.4-0.6 - moderate; >0.6-0.75 - good; >0.75-1.00 - excellent. The significance level (α) considered was 0.05[14].

RESULTS

Volunteers enrolled in the present study were 50% females, predominantly right-handed (90%), physically active (65%) and eutrophic (Table 1).

When comparing the intra-rater reliability (evaluator 1, weeks 1 and 3), good or excellent reproducibility was observed in most of the sites, with both analogue and digital algometers, with statistical significance (Table 2). In the Supraspinatus points of the right (R) and left (L) sides, Pectoralis Major L, Gluteus Medius L, and Paraspinal at 4cm from the midline R and L, moderate but significant correlation was observed with the digital algometer. In the Upper Trapezius L, Supraspinatus R, and Pectoralis Major R sites assessed with the analogue algometer, there was also a moderate and significant correlation.

The inter-device reliability (digital and analogue algometers) showed a significant and excellent correlation ($r > 0.75$) in all evaluated sites for both evaluators (Table 3).

The analysis of inter-rater reliability (2 different evaluators) for the digital algometer revealed good or excellent significant correlation in almost all sites, except for the L pectoralis major ($r=0.585$. $p=0.001$). On the other hand, for the analogue algo-

Table 1. Demographic data (n=40)

	n (%)	Mean ± SD
Gender (F)	20 (50)	
Dominant side (R)	36 (90)	
Physically active	26 (65)	
Exercise days/week*		4.2 ± 1.2
Body mass index		23.9 ± 4.9

SD = Standard deviation; F = females; R = right.
*Among physically active individuals (n=26).

Table 2. Intra-rater intraclass correlation coefficient (weeks 1 and 3)

	Analogue		Digital	
	ICC (r)	p-value	ICC (r)	p-value
R teres major	0.645	0.001	0.743	<0.001
L teres major	0.630	0.001	0.617	0.002
R upper trapezius	0.668	<0.001	0.703	<0.001
L upper trapezius	0.655	<0.001	0.683	<0.001
R levator scapulae	0.678	<0.001	0.635	0.001
L levator scapulae	0.558	0.004	0.613	0.002
R supraspinatus	0.553	0.006	0.573	0.004
L supraspinatus	0.628	0.001	0.552	0.007
R infraspinatus	0.606	0.001	0.635	0.001
L infraspinatus	0.645	<0.001	0.652	<0.001
R pectoralis major	0.588	0.003	0.645	0.001
L pectoralis major	0.688	<0.001	0.575	0.005
R gluteus medius	0.695	<0.001	0.634	0.001
L gluteus medius	0.689	<0.001	0.592	0.004
R paraspinal at 2cm*	0.642	<0.001	0.671	<0.001
L paraspinal at 2cm*	0.643	<0.001	0.687	<0.001
R paraspinal at 4cm*	0.602	0.001	0.530	0.012
L paraspinal at 4cm*	0.621	0.001	0.583	0.001
R deltoid	0.613	0.002	0.776	<0.001
L deltoid	0.601	0.002	0.751	<0.001

ICC = intraclass correlation coefficient; R = right side; L = left side.
*Distance from midline.

Table 3. Inter-device intraclass correlation coefficient between analogue and digital algometers (evaluators 1 and 2)

	Rater 1		Rater 2	
	ICC (r)	p-value	ICC (r)	p-value
R teres major	0.858	<0.001	0.910	<0.001
L teres major	0.829	<0.001	0.882	<0.001
R upper trapezius	0.915	<0.001	0.897	<0.001
L upper trapezius	0.912	<0.001	0.914	<0.001
R levator scapulae	0.908	<0.001	0.952	<0.001
L levator scapulae	0.912	<0.001	0.944	<0.001
R supraspinatus	0.939	<0.001	0.904	<0.001
L supraspinatus	0.945	<0.001	0.902	<0.001
R infraspinatus	0.952	<0.001	0.921	<0.001
L infraspinatus	0.934	<0.001	0.909	<0.001
R pectoralis major	0.912	<0.001	0.817	<0.001
L pectoralis major	0.864	<0.001	0.845	<0.001
R gluteus medius	0.908	<0.001	0.872	<0.001
L gluteus medius	0.916	<0.001	0.859	<0.001
R paraspinal at 2cm*	0.897	<0.001	0.826	<0.001
L paraspinal at 2cm*	0.914	<0.001	0.837	<0.001
R paraspinal at 4cm*	0.944	<0.001	0.878	<0.001
L paraspinal at 4cm*	0.922	<0.001	0.853	<0.001
R deltoid	0.884	<0.001	0.773	<0.001
L deltoid	0.873	<0.001	0.858	<0.001

ICC = intraclass correlation coefficient; R = right side; L = left side.
*Distance from midline.

meter, all evaluated sites exhibited good or excellent correlation with statistical significance (Table 4).

Table 4. Inter-rater intraclass correlation coefficient with analogue and digital algometers.

	Analogue		Digital	
	ICC (r)	p-value	ICC (r)	p-value
R teres major	0.754	<0.001	0.806	<0.001
L teres major	0.743	<0.001	0.790	<0.001
R upper trapezius	0.700	<0.001	0.729	<0.001
L upper trapezius	0.690	<0.001	0.651	0.001
R levator scapulae	0.786	<0.001	0.734	<0.001
L levator scapulae	0.783	<0.001	0.648	0.001
R supraspinatus	0.790	<0.001	0.766	<0.001
L supraspinatus	0.728	<0.001	0.752	<0.001
R infraspinatus	0.775	<0.001	0.795	<0.001
L infraspinatus	0.771	<0.001	0.734	<0.001
R pectoralis major	0.640	<0.001	0.729	<0.001
L pectoralis major	0.698	<0.001	0.585	0.001
R gluteus medius	0.798	<0.001	0.737	<0.001
L gluteus medius	0.794	<0.001	0.745	<0.001
R paraspinal at 2cm*	0.675	<0.001	0.705	<0.001
L paraspinal at 2cm*	0.695	<0.001	0.702	<0.001
R paraspinal at 4cm*	0.778	<0.001	0.735	<0.001
L paraspinal at 4cm*	0.749	<0.001	0.673	<0.001
R deltoid	0.699	<0.001	0.622	<0.001
L deltoid	0.664	0.001	0.609	0.001

ICC = intraclass correlation coefficient. R = right side; L = left side.
*Distance from midline.

DISCUSSION

The aim of this study was to assess reproducibility and reliability of analogue and digital algometers, as quantifying painful experiences is crucial to monitor and diagnose chronic pain[15]. Intra-rater reliability (reproducibility) was good or excellent in most of the sites, with both analogue and digital algometers. Inter-device reliability was also excellent in all evaluated sites. The inter-rater reliability was considered good or excellent in almost all sites for the digital algometer. The analogue algometer produced good or excellent inter-rater reliability in all sites evaluated.

The present study enrolled a homogeneous sample of healthy individuals (university students) with no complaint of pain, so the presence of pain would not interfere in results. Two algometers were tested by two trained evaluators. The analogue algometer has been employed in several studies, e.g. in the assessment of pain in women with dysmenorrhea[16]. The same is true for the digital device, which has been employed, for example, to study pressure pain threshold in healthy individuals submitted to hot and cold compresses[17], and in healthy elderly persons[18].

The digital algometer is recognized as the gold standard pain assessment method[19,20] and has been employed in scientific practices over its analog counterpart due to its increased precision, ease of handling, and result reading. However, in clinical routine, the cost of the equipment may hinder its utilization[20]. For this reason, both algometers were subjected to an investigation in this study.

A recent study[21] examined the reproducibility of digital algometers among experienced and novice evaluators, and found minor differences after 3 hours of practice, indicating good a reproducibility in determining PPT, like to the present study. In this investigation, intra-examiner reproducibility of both digital and analogue algometers revealed good to excellent reproducibility, underscoring the consistency of results upon repeated examinations. It is noteworthy that test reliability was measured over a 2-week period, a timeframe reasonably compatible with clinical practice assessments.

Unlike a study[22] who used a digital algometer to evaluate the medial part of the proximal tibia metaphysis of healthy individuals, the present study focused sites at the hip, spine, and shoulder regions. Nonetheless, both studies agree, since algometry performed with electronic devices provides good or excellent reliability. The data of this study also corroborates the aforementioned study since the high reliability of makes it a valuable tool for longitudinal assessments, providing a reliable means of tracking individuals over time.

Examining the accordance between devices, a notable and excellent correlation (above 0.75) was observed at all points. This robust correlation across different evaluators underscores the reliability of values between the two types of algometers, affirming the usability of both. This result is significant, instilling confidence when digital algometry is not feasible, and indicating that analogue algometers can be employed not only in clinical settings but also in scientific research.

Regarding intra-evaluator reliability, results were highly positive, with values showing good to excellent correlation. This implies that examinations performed with both analogue and digital algometers can be conducted by different evaluators when necessary. This is crucial for monitoring a patient's progress despite changes in the clinical environment or in evaluators/therapists, especially in multicenter studies, as emphasized by a study[23].

The findings of this study align with a relevant study[24], which evaluated intra-rater and inter-rater reliability of PPT measurement by a handheld algometer at various body locations. They found excellent intra-rater (ICC=0.81-0.99) and inter-rater reliability (ICC=0.92-0.95), supporting the usefulness of multiple trained evaluators in large cohort studies with standardized protocols.

It is worth noting that this study chose to evaluate young, healthy individuals, and this may be seen as a possible limi-

tation, as it prevents the extrapolation of data to other populations. However, emerging studies indicate the applicability of digital algometry in clinical conditions such as stroke, where a study[25], for instance, also demonstrated good to excellent reliability. Similarly, in cervical and low back pain, a study[26] suggested that the method is important for detecting progress after interventions, and another study[1] demonstrated that algometry is a suitable method for pain assessment in osteoarthritis patients, exhibiting good intra-rater and acceptable inter-rater reliabilities after brief training sessions. Algometry, a low cost and fast evaluation of PPT, should be encouraged in the clinical practice of healthcare professionals who deal with pain assessment. Besides allowing the monitoring of a disease and/or clinical condition under therapeutic intervention, the technique is reliable, whether conducted with a digital or an analogue algometer, and even if the patient is evaluated by another trained professional. Furthermore, it can assist professionals in quantifying pain and understanding conditions of hypo- or hyperalgesia in various clinical settings.

CONCLUSION

In conclusion, the data of this research highlight that digital and analogue algometry have good intra-rater reliability (reproducibility), inter-device reliability and inter-rater reliability in a sample of healthy young individuals. It is suggested that future studies are conducted with other populations, especially elderly persons, who are the most vulnerable group to chronic pain syndromes.

AUTHORS' CONTRIBUTIONS

Natália Cristina de Oliveira
Statistical Analysis, Conceptualization, Research, Methodology, Writing - Preparation of the original, Validation
Klara Reis Silva
Data Collection, Research, Writing - Preparation of the original
Adna Costa Santos
Data Collection, Research, Writing - Preparation of the original
Fábio Marcon Alfieri
Resource Management, Project Management, Methodology, Writing - Review and Editing, Supervision, Validation

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