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ΕΡΕΥΝΗΤΙΚΗ ΕΡΓΑΣΙΑ

# Validity and reliability of body maps for the assessment of pain distribution in patients with chronic neck pain

OBJECTIVE **The investigation of the test-retest and inter-rater reliability of digital and paper body maps for recording pain distribution in patients with chronic neck pain.** METHOD **Two different raters completed one digital (pain distribution analysis software) and three paper body maps (Margolis, body grid, and Michigan body map) based on the pain distribution (pain extent and location) that had been previously recorded in 45 patients with idiopathic chronic neck pain. One of the two raters completed (again) the four different body maps one month after their initial completion.** RESULTS **In terms of pain extent, test-retest reliability of the body maps was found to be good to excellent (intraclass correlation coefficient [ICC]=0.76–0.92), whereas their inter-rater reliability was found to be moderate to excellent (ICC=0.59–0.92). In terms of pain location, it was found that there was a very good to excellent test-retest (84.4–100%) and inter-rater (77–100%) agreement. The correlations between all the pain distribution indices were significantly strong to very strong (r=0.74–0.99).** CONCLUSIONS **Paper and digital body maps can offer reliable estimates of pain distribution in patients with idiopathic chronic neck pain.**

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ΑΡΧΕΙΑ ΕΛΛΗΝΙΚΗΣ ΙΑΤΡΙΚΗΣ 2026, 43(1):94–100

**Z. Dimitriadis,[1]**
**N. Konstantinou,[1]**
**D. Karageorgiou,[1]**
**E. Kapreli,[2]**
**A. Kanellopoulos,[1]**
**I. Poulis,[3]**
**E. Tsipra,[4]**
**J. Oldham,[5]**
**N. Strimpakos[1]**

*[1]Laboratory of Health Assessment and Quality of Life, Department of Physiotherapy, School of Health Sciences, University of Thessaly, Lamia*
*[2]Laboratory of Clinical Exercise Physiology and Rehabilitation, Department of Physiotherapy, School of Health Sciences, University of Thessaly, Lamia*
*[3]Laboratory of Human Performance and Rehabilitation, Department of Physiotherapy, School of Health Sciences, University of Thessaly, Lamia*
*[4]Clinic of Physiorelax Physiotherapy, Peristeri, Attica, Greece*
*[5]Manchester Academic Health Sciences Centre, University of Manchester, Manchester, United Kingdom*

Εγκυρότητα και αξιοπιστία των χαρτών σώματος για την αξιολόγηση της κατανομής του πόνου σε ασθενείς με χρόνιο αυχενικό πόνο

*Περίληψη στο τέλος του άρθρου*

**Key words**

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Pain has been defined by the International Association for the Study of Pain (IASP) as *"an unpleasant sensory and emotional experience associated with, or resembling that associated with actual or potential tissue damage".*[1] Chronic pain persists for more than the normal healing time of the tissues which, in the absence of other factors, it is usually

considered to be three months.[2] It commonly presents as a result of disease or injury and is a common, complex and distressing problem with a considerable impact on individuals and society.[3] Chronic pain leads to an enormous personal and economic burden and it is estimated to affect more than 30% of people worldwide.[4] Considering years lived with disability, neck and low back pain are the leading causes of disability.[3,5]

Pain distribution is an important aspect of pain assessment and it is usually described via the recording of pain extent and location.[6] The recording and assessment of pain distribution is important for clinicians and researchers who are invested in the management of musculoskeletal pain conditions.[7,8] Pain distribution can be used as prognostic factor of certain diseases and or recovery, as an outcome measure for monitoring the improvement of patients,[8] as well as a diagnostic marker of central sensitization.[9,10] The recording and assessment of pain distribution necessitates the existence of valid and reliable assessment tools in order to be confidently used in clinical practice and research.

Literature describes a number of methods for recording pain distribution.[8,11,12] Pain drawings on a body map are extensively used for this purpose. In these body maps, patients are asked to draw where they feel pain in order to obtain an accurate graphic representation of their pain distribution.[10,12] Pain drawings are usually performed with a pen-and-paper method,[13,14] but recent advances in technology have allowed for the use of digital body maps.[10,12,15]

Although the importance of body maps as a tool for recording pain distribution is indisputable, the evidence about their validity and reliability is not well established. This becomes especially evident when the question about their validity and reliability is concerned with more homogenous clinical populations and not for the general population of patients with pain. Chronic neck pain is one of the most frequent musculoskeletal complaints and the examination of psychometric properties of paper and digital body maps for recording pain distribution to this population seems to be of high significance. Therefore, the study was aimed at examining (a) the test-retest and inter-rater reliability of three different well-known paper body maps for recording pain distribution in patients with idiopathic chronic neck pain, (b) the test-retest and inter-rater reliability of a recently developed software with a digital body map for recording pain distribution in patients with idiopathic chronic neck pain and (c) the concurrent validity of the three different paper body maps with the recently developed digital body map.

## MATERIAL AND METHOD

### Sample

The sample was composed of 45 vignettes which were designed based on the body maps of 45 real patients with idiopathic chronic neck pain who participated in previously published studies.[16–18] In short, these patients had a six-month history of idiopathic neck pain and were between 18- and 65-year-old. Patients with spinal or chest surgeries, clinical abnormalities of the spine or thorax, with pain on other body regions, smokers, with obesity, with professional exposure in irritating substances for their respiratory system, with severe cardiovascular, pulmonary, neuromusculoskeletal, neurological, mental and metabolic diseases and malignancies had been excluded. The study was in accordance with the Declaration of Helsinki (1975). The study was approved by the Deontology Committee of the Physiotherapy Department, School of Health Sciences, University of Thessaly, Greece (650/9.9.2021).

### Equipment and materials

In this study, one digital and three different paper body maps were used for recording pain distribution of the patients.

The first paper body map was based on the Margolis method for recording pain distribution.[13,19,20] According to this method, the body is divided in 45 different numbered anatomical regions. Each of these regions should be marked in case there is pain in this region. The whole region is marked independently of the percentage of the painful area of this region. The map is double-sided and therefore the painful regions are marked for both the anterior and posterior body part. The indices of pain distribution that were calculated include: (a) the number of painful regions ($n_{MM}$), (b) the % percentage of pain distribution[13] ($\%PD_{MM}$) and (c) the existence of pain for each body region in a dichotomous scale (yes/no).

The second paper body map was based on a grid (body grid method).[14] This grid covers the anterior and posterior body part with small squares of equal size. After the pain pattern is marked on the body, the number of the marked squares ($n_{BGM}$) was counted and recorded as the index of pain distribution.

The third paper body map was the revised Michigan body map.[21] This is a double-sided body map with 35 squares that each one represents an anatomical region. In case of persistent or recurrent pain in a body region, this body region is marked with a check mark (√). The number of checked body regions ($n_{MBP}$) was used as the index of pain distribution.

The digital body map was included on the Pain Distribution Drawing Analysis software.[10] The software provides a double-sided genderless body image. The reference image is in high definition, counting 1,517,036 pixels for the total area of the two body sides and it has been designed according to the Rule of Nines for Burn. The software uses only the drawings that are inside the boundaries

of the body map and calculates the ratio of the number of pixels of this area to the number of pixels of the whole body map. This ratio is the % percentage of pain distribution area (%$PD_{soft}$). Furthermore, the software provides the selection for "smart selected area calculations" in order to colour the areas that were intended to be colored, but left uncolored, so that to be included in the calculation of the % percentage of pain distribution area (%$PD_{soft\text{-}smart}$). The software has been designed so that the body maps can be drawn with the use of a digital tablet and stylus pen, but a conventional mouse can also be used on a personal computer.

### Procedure

Initially, 45 vignettes were designed based on real body maps from 45 patients with idiopathic chronic neck pain who participated in previously published studies.[16–18] The vignettes included body maps with the real pain distribution of each patient as it was recorded in the initial study. Furthermore, there was available information about the real demographic characteristics, pain condition, disability and psychological states of the corresponding patients.

The vignettes were assessed by two raters. Both raters were postgraduate physiotherapists with clinical experience in spinal pain. The first rater (rater A) used the four body maps (three paper, one digital) to record the pain distribution which was described in the 45 vignettes. The digital body maps were drawn with the use of an optical mouse on a laptop. In order to avoid potential memory bias, the assessment of the 45 vignettes with a body map had to be completed, before the next body map could be used for further assessment. The same time, the same procedure was performed by a second rater (rater B) who was blind to the recordings of the rater A. One month after the completion of the assessment by the rater A, the same rater repeated exactly the same procedure.

### Statistical analysis

Descriptive statistics were presented by using means (M), standard deviations (SD) and percentages (%).

Test-retest and inter-rater reliability of the four body maps for recording pain distribution (pain extent dimension) were examined with the second model of the intraclass correlation coefficient ($ICC_{2,1}$), as well the standard error of measurement (SEM) and smallest detectable difference (SDD). The same indices were also expressed as % percentages of the grand mean. The concurrent validity between the different body maps was examined with Pearson (r) correlation coefficients.

The test-retest and inter-rater reliability of each pain region (pain location dimension) recorded with the use of Margolis body map was examined with the calculation of percentage agreement. Kappa (κ) was not reported due to the fact that dispersion of data was not appropriate for this test (the ratings in many occasions were presented as constant).

ICC values were interpreted as poor (0–0.5), moderate (0.5–0.75), good (0.75–0.90) and excellent (0.90–1.00).[22] SEM values of <15% of the grand mean and SDD values of <30% of the grand mean were considered satisfactory.[23,24] Pearson correlation coefficients were interpreted as very weak (0–0.19), weak (0.20–0.39), moderate (0.40–0.59), strong (0.60–0.79) or very strong (0.80–1.00).[25]

Significance level was set at p=0.05. All data analysis was performed with the Statistical Package for Social Sciences (SPSS), version 22.0.

## RESULTS

The clinical characteristics and demographics of the 45 patients with idiopathic chronic neck pain have been analytically described in previous publications.[16–18,26,27] In short, the patients were young (age: 35.9±14.5 years) and mainly females (male/female: 13/32) with neck pain for 69.6±57.6 consecutive months, mild to moderate usual pain intensity (visual analogue scale [$VAS_{pain}$]: 45.5±18.8 mm) and mild disability (neck disability index [NDI]: 10.6±5.2).

Test-retest reliability was found to be good for the %$PD_{MM}$, %$PD_{soft}$, %$PD_{soft\text{-}smart}$ and $n_{MBP}$ (ICC=0.76–0.88) and excellent for the $n_{BGM}$ and $n_{MM}$ (ICC=0.90–0.92) (tab. 1). Inter-rater reliability was found to be moderate for the %$PD_{soft}$ and %$PD_{soft\text{-}smart}$ (ICC=0.59–0.72), good for the $n_{BGM}$ and $n_{MBP}$ (ICC=0.86–0.89) and excellent for the %$PD_{MM}$ and $n_{MM}$ (ICC=0.91–0.92) (tab. 2). The correlations between all the pain distribution indices were significantly strong to very strong (r=0.74–0.99, p<0.05) (tab. 3).

The recording of pain location with the use of Margolis body map presented high agreement between the different sessions (test-retest agreement: 84.4–100%) and between the different raters (inter-rater agreement: 77.7–100%) for the most body regions (fig. 1).

**Table 1.** Test-retest reliability of the four different body maps for recording pain distribution (pain extent) in patients with idiopathic chronic neck pain.

| PDI | GM | ICC | 95% CI | SEM/SEM% | SDD/SDD% |
|---|---|---|---|---|---|
| %$PD_{soft}$ | 1.22 | 0.76 | 0.09, 0.91 | 0.35/28.6% | 0.97/79.5% |
| %$PD_{soft\text{-}smart}$ | 1.43 | 0.79 | 0.25, 0.92 | 0.46/32.1% | 1.27/88.8% |
| %$PD_{MM}$ | 7.67 | 0.89 | 0.78, 0.95 | 1.65/21.5% | 4.57/59.5% |
| $n_{MM}$ | 5.03 | 0.92 | 0.75, 0.97 | 0.64/12.7% | 1.77/35.1% |
| $n_{BGM}$ | 9.63 | 0.90 | 0.77, 0.95 | 1.47/15.2% | 4.07/42.2% |
| $n_{MBP}$ | 3.03 | 0.88 | 0.79, 0.93 | 0.58/19.1% | 1.61/53.1% |

PDI: Pain distribution index, GM: Grand mean, ICC: Intraclass correlation coefficient, 95% CI: 95% confidence intervals, SEM: Standard error of measurement, SDD: Smallest detectable difference, %$PD_{soft}$: % percentage of pain distribution area with the pain distribution software, %$PD_{soft\text{-}smart}$: % percentage of pain distribution area with the pain distribution software after the selection of "smart selected are calculations", %$PD_{MM}$: % percentage of pain distribution area based on Margolis method, $n_{MM}$: Number of painful regions according to Margolis method, $n_{BGM}$: Number of marked squares with the body grid method, $n_{MBP}$: Number of painful areas recorded on Michigan body map

**Table 2.** Inter-rater reliability of the four different body maps for recording pain distribution (pain extent) in patients with idiopathic chronic neck pain.

| PDI | GM | ICC | 95% CI | SEM/SEM% | SDD/SDD% |
|---|---|---|---|---|---|
| $\%PD_{soft}$ | 2.17 | 0.59 | 0.0, 0.83 | 0.81/37.3% | 2.25/103.6% |
| $\%PD_{soft\text{-}smart}$ | 2.29 | 0.72 | 0.04, 0.90 | 0.67/29.2% | 1.86/81.2% |
| $\%PD_{MM}$ | 7.85 | 0.91 | 0.84, 0.95 | 1.51/18.2% | 4.18/53.2% |
| $n_{MM}$ | 5.10 | 0.92 | 0.82, 0.96 | 0.72/14.1% | 1.99/39.0% |
| $n_{BGM}$ | 9.61 | 0.89 | 0.74, 0.95 | 1.50/15.6% | 4.16/43.2% |
| $n_{MBP}$ | 2.97 | 0.86 | 0.74, 0.93 | 0.60/20.2% | 1.66/55.8% |

PDI: Pain distribution index, GM: Grand mean, ICC: Intraclass correlation coefficient, 95% CI: 95% confidence intervals, SEM: Standard error of measurement, SDD: Smallest detectable difference, $\%PD_{soft}$: % percentage of pain distribution area with the pain distribution software, $\%PD_{soft\text{-}smart}$: % percentage of pain distribution area with the pain distribution software after the selection of "smart selected are calculations", $\%PD_{MM}$: % percentage of pain distribution area based on Margolis method, $n_{MM}$: Number of painful regions according to Margolis method, $n_{BGM}$: Number of marked squares with the body grid method, $n_{MBP}$: Number of painful areas recorded on Michigan body map

**Table 3.** Concurrent validity of each PDI with the other PDI. Associations have been expressed with Pearson correlation coefficients (r).

| PDI | $\%PD_{soft}$ | $\%PD_{soft\text{-}smart}$ | $n_{MM}$ | $\%PD_{MM}$ | $n_{BGM}$ | $n_{MBP}$ |
|---|---|---|---|---|---|---|
| $\%PD_{soft}$ | – | 0.99** | 0.75* | 0.75* | 0.86* | 0.78* |
| $\%PD_{soft\text{-}smart}$ | 0.99** | – | 0.74* | 0.74* | 0.85* | 0.75* |
| $n_{MM}$ | 0.75* | 0.74* | – | 0.86* | 0.78* | 0.81* |
| $\%PD_{MM}$ | 0.75* | 0.74* | 0.86* | – | 0.78* | 0.79* |
| $n_{BGM}$ | 0.86* | 0.85* | 0.78* | 0.78* | – | 0.75* |
| $n_{MBP}$ | 0.78* | 0.75* | 0.81* | 0.79* | 0.75* | – |

*p<0.01, **p<0.001

PDI: Pain distribution index, $\%PD_{soft}$: % percentage of pain distribution area with the pain distribution software, $\%PD_{soft\text{-}smart}$: % percentage of pain distribution area with the pain distribution software after the selection of "smart selected are calculations", $\%PD_{MM}$: % percentage of pain distribution area based on Margolis method, $n_{MM}$: Number of painful regions according to Margolis method, $n_{BGM}$: Number of marked squares with the body grid method, $n_{MBP}$: Number of painful areas recorded on Michigan body map

## DISCUSSION

The findings of the study showed that both paper and digital body maps can provide reliable recordings of pain distribution in patients with idiopathic chronic neck pain. Their test-retest reliability was good to excellent and their inter-rater reliability was moderate to excellent. The SEM values were acceptable for the most indices, whereas they were slightly more than 30% only for some indices related to digital body maps. The concurrent validity of paper with digital body maps was also found to be strong.

According to our knowledge, this was the first study which examined both test-retest and inter-rater reliability

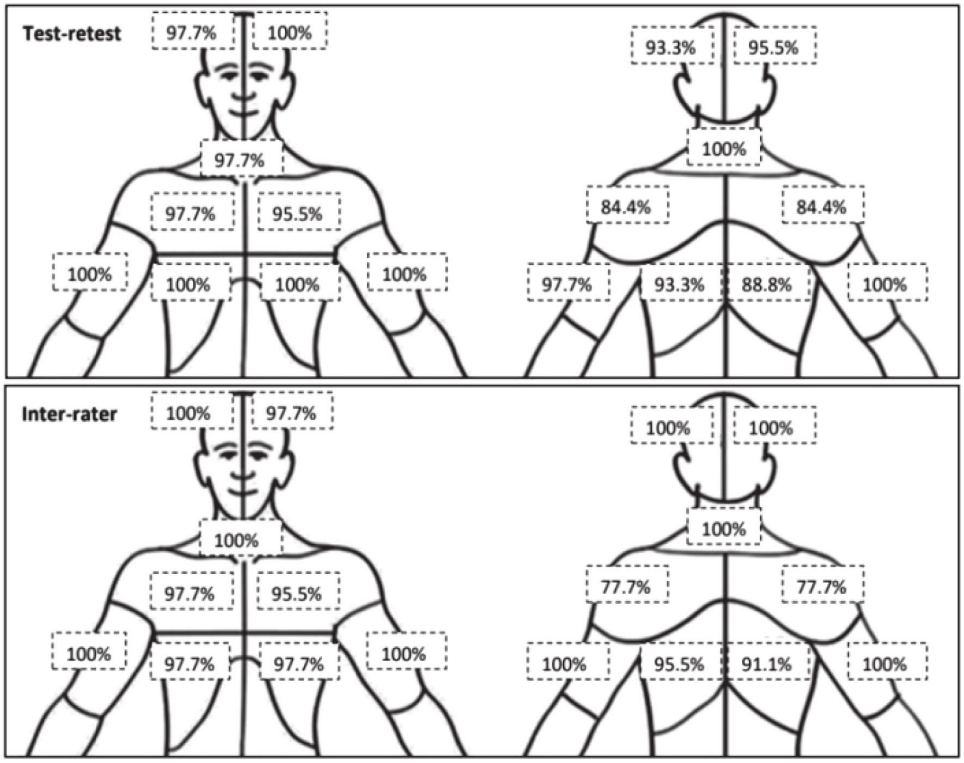


**Figure 1.** Test-rest and inter-rater agreement for the recording of pain distribution (pain location) based on Margolis body map in patients with idiopathic chronic neck pain (values in the body charts represent percentage agreement).

(including information about their ICC, SEM and SDD) for both digital and the most widely used paper body maps in patients with idiopathic chronic neck pain with the parallel examination of the concurrent validity of the methods. This complete examination of the different methods for recording pain distribution in patients with chronic neck pain allowed for a direct comparison of the psychometric properties of the methods.

A systematic review[8] about the reliability of body pain diagrams for the recording of pain distribution in patients with musculoskeletal pain did not detect any study which was performed in a sample of patients with neck pain. The samples of the review studies that were closest to the sample of the current study, included patients with low back pain, shoulder pain or non-regionally defined chronic pain. The review showed that the test-retest reliability of the body maps for recording pain distribution may range from moderate to excellent (ICC=0.58–0.94), something that is in agreement with the findings of our study.

The only other existent evidence for the reliability of the same software comes from another study in patients with shoulder pain.[28] The test-retest reliability of the digital body map for recording pain extent in patients with shoulder pain (ICC=0.8, 95% confidence interval [CI]=0.60–0.91) was found to be similar to the test-retest reliability estimates of the current study. The common findings regarding the reliability of the digital body map in both patients with shoulder and neck pain was a positive sign regarding its generalizability in populations with pain in other body regions.

The reliability of digital body maps for recording pain distribution in patients with chronic neck pain has also been previously examined in two studies.[15,20] The authors of the first study[20] examined the inter-rater reliability of a paper (Margolis) body map, as well as its electronic version for recording pain distribution in patients with whiplash-associated disorders. They found excellent inter-rater reliability for both methods (paper body map ICC=0.92, 95% CI=0.90–0.94, electronic version ICC=0.997, 95% CI=0.995–0.998). The findings of the present study were in agreement about the excellent inter-rater reliability of the Margolis body map although the estimates in the other study[20] were higher.

The second study[15] showed that the digital body maps present excellent reliability in chronic neck pain (ICC=0.92, 95% CI=0.87–0.98). Although the conclusions of our study are in agreement with this study,[15] the test-retest reliability estimates in the other study were higher than the reliability estimates of the present study. This difference in reliability estimates might be attributed to many reasons including the different software used, the fact that the body maps were directly drawn from the patients, the different time intervals between the test and retest session leading to different levels of recall bias and the use of a digital tablet and a stylus pen rather than a laptop and a mouse for drawing the body maps.

The findings of the study showed that the $\%PD_{soft\text{-}smart}$ can be a more reliable index of pain distribution in comparison with $\%PD_{soft}$. Although theoretically the use of $\%PD_{soft\text{-}smart}$ may not be always appropriate, such as in cases when pain appears circular surrounding a non-painful area, this does not seem to be the case in the sample of patients of the current study. On the contrary, the use of $\%PD_{soft\text{-}smart}$ can reduce the amount of error induced by the drawing abilities of the examiners. Therefore, based on these findings, $\%PD_{soft\text{-}smart}$ is the recommended index of the software for recording pain distribution of patients with chronic neck pain.

It is important to be clarified that the error that was described with the reliability indices of our study is concerned with the transcription of the body maps drawings. When the reliability of body maps is examined by asking patients to draw their pain, a considerable amount of the resulting error may derive from patients. For example, the understanding of patients about the exact pain distribution, the ability of patients to match the pain distribution in their body with the pain distribution in the body chart and the drawing abilities of the patients are all sources of error. This patient-related error has not been examined in the current study. Therefore, the error of the procedure should be sought in other sources and mainly to the ability of the raters to accurately draw patients' pain distribution on a map.

In addition, the examination of the reliability of the body maps via transcription eliminates a very important threat to internal validity which would be otherwise very difficult to overcome. More specifically, patients with pain may have changes in their pain condition between the test and retest session. These changes may affect the reliability indices and lead to erroneous conclusions about the reliability of the body maps used. In our study, the same original recordings were used for both the test and retest session and therefore, such a threat was non-existent.

The study had certain limitations that should be taken into consideration during the interpretation of the results. The body maps were drawn with the use of an optical mouse on a laptop. Although this is acceptable, it has been suggested that the body maps should be colored with the use of a stylus pen on a tablet. This could potentially provide

the possibility for more accurate recordings and therefore may affect the reliability of the procedure. Furthermore, the study included only body maps from patients with chronic neck pain. Although this may reduce the generalizability of the findings only to patients with pain experienced in the specific anatomic region, the results seem to be also quite relevant to patients with pain in other anatomical regions as this is not believed to considerably change the properties of the instruments.

Despite the important clinical implications, the findings and conclusions from the current study give rise to important questions that should be addressed in future studies. An important question is the examination of the error that is implicit in the drawing of body maps in comparison with the error induced in the procedure by other sources when they are completed by patients in real time. Furthermore, it would be important to examine the reliability of the digital body map by using a tablet and stylus pen as this is a more applicable and potentially more reliable method when directly examining musculoskeletal patients in clinics. Last, the research questions of the present study should be examined in musculoskeletal patients with pain in other body regions as this could change the reliability estimates. The investigation of such research questions could lead to better clinical reasoning regarding the use of body maps and the interpretation of their findings.

## ΠΕΡΙΛΗΨΗ


### Εγκυρότητα και αξιοπιστία των χαρτών σώματος για την αξιολόγηση της κατανομής του πόνου σε ασθενείς με χρόνιο αυχενικό πόνο



Ζ. ΔΗΜΗΤΡΙΑΔΗΣ,[1] Ν. ΚΩΝΣΤΑΝΤΙΝΟΥ,[1] Δ. ΚΑΡΑΓΕΩΡΓΙΟΥ,[1] Ε. ΚΑΠΡΕΛΗ,[2] Α. ΚΑΝΕΛΛΟΠΟΥΛΟΣ,[1] Ι. ΠΟΥΛΗΣ,[3] Ε. ΤΣΙΠΡΑ,[4] J. OLDHAM,[5] Ν. ΣΤΡΙΜΠΑΚΟΣ[1]

*[1]Ερευνητικό Εργαστήριο Αξιολόγησης της Υγείας και της Ποιότητας Ζωής, Τμήμα Φυσικοθεραπείας, Σχολή Επιστημών Υγείας, Πανεπιστήμιο Θεσσαλίας, Λαμία, [2]Ερευνητικό Εργαστήριο Κλινικής Φυσιολογίας της Άσκησης και Αποκατάστασης, Τμήμα Φυσικοθεραπείας, Σχολή Επιστημών Υγείας, Πανεπιστήμιο Θεσσαλίας, Λαμία, [3]Ερευνητικό Εργαστήριο Ανθρώπινης Δραστηριότητας και Αποκατάστασης, Τμήμα Φυσικοθεραπείας, Σχολή Επιστημών Υγείας, Πανεπιστήμιο Θεσσαλίας, Λαμία, [4]Εργαστήριο Φυσικοθεραπείας "Physiorelax", Περιστέρι, [5]Manchester Academic Health Sciences Centre, University of Manchester, Manchester, Ηνωμένο Βασίλειο*


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**ΣΚΟΠΟΣ** Η διερεύνηση της αξιοπιστίας ελέγχου-επανελέγχου και της διαβαθμολογικής αξιοπιστίας των ψηφιακών και των έντυπων χαρτών σώματος για την καταγραφή της κατανομής του χρόνιου αυχενικού πόνου. **ΥΛΙΚΟ-ΜΕΘΟΔΟΣ** Δύο διαφορετικοί αξιολογητές συμπλήρωσαν έναν ψηφιακό (pain distribution analysis software) και τρεις έντυπους χάρτες σώματος (Margolis, body grid και Michigan body map) βάσει της κατανομής του πόνου (έκταση και περιοχή πόνου) που είχε προηγουμένως καταγραφεί σε 45 ασθενείς με χρόνιο αυχενικό πόνο. Ένας από τους δύο αξιολογητές συμπλήρωσε ξανά τους τέσσερις διαφορετικούς χάρτες σώματος έναν μήνα μετά την αρχική συμπλήρωση. **ΑΠΟΤΕΛΕΣΜΑΤΑ** Όσον αφορά στην έκταση του πόνου, η αξιοπιστία ελέγχου-επανελέγχου των χαρτών σώματος βρέθηκε καλή έως άριστη (ICC=0,76–0,92), ενώ η διαβαθμολογική τους αξιοπιστία βρέθηκε μέτρια έως άριστη (ICC=0,59–0,92). Όσον αφορά στην περιοχή του πόνου, βρέθηκε ότι υπάρχει πολύ καλή έως άριστη συμφωνία μεταξύ των δύο συνεδριών αξιολόγησης (84,4–100%) και μεταξύ των δύο αξιολογητών (77–100%). Οι συσχετίσεις μεταξύ όλων των δεικτών κατανομής του πόνου παρουσιάστηκαν ως ισχυρές έως πολύ ισχυρές (r=0,74–0,99). **ΣΥΜΠΕΡΑΣΜΑΤΑ** Οι έντυποι και οι ψηφιακοί χάρτες σώματος μπορούν να δώσουν αξιόπιστες καταγραφές της κατανομής του πόνου σε ασθενείς με ιδιοπαθή χρόνιο αυχενικό πόνο.


**Λέξεις ευρετηρίου:** Αξιοπιστία, Εγκυρότητα, Έκταση πόνου, Περιοχή πόνου, Συμφωνία

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*Corresponding author:*

Z. Dimitriadis, Department of Physiotherapy, University of Thessaly, 3rd km Old National Road Lamia-Athens, 351 00 Lamia, Greece
e-mail: zdimitriadis@uth.gr