Profiling the location and extent of musicians' pain using digital pain drawings

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1. Introduction

The training needed to reach and maintain the highest levels of performance can expose musicians to a wide range of musculoskeletal health problems. Indeed, the acquisition and improvement of performance skills have been shown to expose musicians' bodies, continuously and repeatedly, to contorted positions and unnatural movements.[1] Not surprisingly, musicians are vulnerable to developing musculoskeletal disorders [2-4] and to experiencing a range of physical problems, such as pain, weakness, and numbness that can affect how and how much they make music.[2,5]

Although there are sporadic historical cases of scientific studies of the health of musicians[6,7] the growth of performing arts medicine as a speciality field has occurred mainly over the last 30 years. In 1986, the concert pianist Gary Graffman published an article in the *New York Times* on his own focal dystonia and his difficulties in finding suitable treatment[8]. Since then, large-scale surveys of musicians have reported a high prevalence of performance-related ill health.[1,9] This phenomenon was described by Zaza, Charles, and Muszynski[10] as *playing-related musculoskeletal disorders* (PRMDs) and includes any pain, weakness, numbness, tingling, or other physical symptoms that affect a musicians' capacity to sing or to play their instruments at the level they are accustomed to.

The existing research shows that PRMDs are commonly experienced both by professional musicians[9,11,12] and by advanced music students.[13-15] For instance, international surveys have reported the lifetime prevalence of PRMDs among orchestral musicians as between 39% and 87%;[10,16] with the majority of studies reporting figures in the upper portion of this range. Among advanced students, the prevalence is similarly between 32% and 89%.[17]

Pain, as a main complaint among musicians with PRMD, has been investigated mainly in terms of its location[18-20], prevalence[4,21-23] and sometimes intensity.[22,24-27] The broad conception of pain found in the performing arts medicine literature is reflected in the variety of measures used to study it. For instance, investigations with musicians often rely on validated questionnaires for the general population, such as the DASH, which measures upper-extremity disability and symptoms[4,28,29], the Standardised Nordic Questionnaire, which measures pain location[4,21-23,30], or the SF-12, which measure general physical and mental health.[28,31,32] Bespoke surveys have also been constructed,[11,13,24,33] and interviews have been used to shed light on experiences of pain within the wider context of professional life.[34,35] In addition, some studies have employed physical tests specifically designed for musicians.[2,11,16]

Outside of the performing arts, recent advancements in technology have led to new digital methods of recording pain location and extent.[36,37] The method involves a user-friendly interface made available on a tablet that contains a collection of body charts and customized software to analyse digital pain drawings (PDs). Using established protocols, people report their pain by drawing on different templates representing the human body (i.e. body charts). Although not yet applied within the performing arts, digital PDs have become an important component in the assessment of pain and are now widely used to capture the location of pain and to assess its extent.[36,38,39] Indeed, due to the lack of accuracy and reliability during the acquisition and analysis procedures of traditional paper body charts,[40-45] digital PDs are now recommended.[46]

This study sought to employ digital PDs for the first time in a large-scale study of musicians' pain. The purpose of this study was to investigate the location and the extent of pain of a sample of musicians using a digital tablet for PD acquisition. Additionally, the association between PD variables (i.e. pain location and pain extent) and musicians' features were explored.

2. Methods

This study forms part of Musical Impact (2013-17), an interdisciplinary project investigating the health and wellbeing of musicians studying and working in Europe. The project has three core strands: (1) *Fit to Perform* explores the attitudes, perceptions, and behaviours of musicians toward health and wellbeing, as well as their experience of chronic and acute health problems and their general fitness for performance; (2) *Making Music* investigates the physical and mental demands faced by musicians as they practise and perform; and (3) *Better Practice* examines strategies for promoting health effectively in music educational and professional contexts. This article focuses on *Fit to Perform* and, specifically, on self-reports of pain extension and location using digital PDs. The research was granted ethical approval by the Conservatoires UK Research Ethics Committee and was conducted according to ethical guidelines of the British Psychological Society. Informed written consent was obtained from all participants prior to data collection, and no payment was given in exchange for participation.

2.1. Participants

In total 158 musicians (90 women, 68 men) were recruited from the Conservatory of Southern Switzerland (CSI, n=68), Royal College of Music (RCM, n=32), Royal Conservatoire of Scotland (RCS, n=16), Royal Central School of Speech and Drama (RCSSD, n=19), Royal Welsh College of Music and Drama (RWCMD, n=13), and Southbank Sinfonia (SBS, n=10). The mean age of the musicians was 22.4 years (SD ±3.6, range 17-41), 22.4 years (SD ±3.2) for women and 22.5 years (SD ±4.2) for men.

Inclusion criteria for participants were undergraduate and postgraduate professional music students (both women and men). Exclusion criteria included reports of clinically relevant conditions (i.e. any neurological and rheumatic disorders) or any cognitive disorders that may have influenced spatial perception and the completion of the pain drawings.

None of which applied to the recruited participants.

At the time of the study, 59 participants were undergraduate students (mean age=19.7 SD ±2.3; Year 1 n=42, Year 2 n=5, Year 3 n=6, Year 4 n=6), 89 were postgraduate students (mean age=23.9, SD ±3.4; Year 1=62; Year 2=23; Year 3=4), and 10 were members of a professional ensemble on a one-year post-graduation contract from the Southbank Sinfonia (mean age=25.4; SD ±2.1).

2.2. Materials

2.2.1. Background and musical information

General background questions elicited information on participants' age, sex, nationality, principle instrument, career status, year of study, and institution. Information on height, and weight, and the average number of hours per week devoted to practicing was also obtained.

2.2.2. Quick DASH (QD)

The Quick DASH is an 11-item questionnaire used to measure physical function and symptoms in persons with musculoskeletal disorders of the upper limb.[47,48] It is a reliable, shortened version of the 30-item DASH Outcome Measure (Cronbach $\alpha = 0.94$). Respondents rate each item based on their experience over the preceding week on a 5-point Likert-type scale, increasing from 1 to 5 in level of difficulty/severity. Responses are averaged and then transformed into an overall disability/symptom score out of 100, where higher scores indicate greater disability. An optional module, specifically designed for athletes and performing artists, was also used in this study; it consists of four items, to which the same steps are applied to generate a separate score out of 100.

2.2.3. Digital pain drawings (PDs)

PDs were completed on a digital interface (Apple iPad 2) using a stylus pen designed for tablets (CS100B, Wacom, Vancouver, WA, USA) and a commercially available sketching software (SketchBook Pro). The reliability of this novel approach to assess pain has been confirmed in both chronic patients and in case of acute painful stimuli (36 e 37).

A collection of male and female body charts of the upper body with two different views (frontal and dorsal) were used (see Figure 1) and saved within the sketching software. All body charts have a closed perimeter and were reported on paintings with a size of 768x1024 pixels. The type, size and colour of the pen strokes were standardized across all participants. Using customised software for the analysis of PDs, *pain extent* expressed as the number of pixels coloured inside the frontal and dorsal body charts (the total area of pain for each participant) and *pain frequency maps* were computed. The pain frequency map is a function in which all the PDs are overlaid and analysed simultaneously to indicate the most frequently reported location of pain across the entire sample. A colour grid was used to illustrate the percentage of participants that reported pain in a specific area.[37] This was computed for women and men separately.

[INSERT FIGURE 1 ABOUT HERE]

2.3. Procedure

Musicians were recruited in person and via email to take part in the study. Initially, participants were sent a detailed information sheet, and sessions were arranged to take place across each of the participating institutions, at a pre-arranged date and time. Following this, participants were asked to complete the survey with general background questions, as well as the Quick Dash. Following this assessment, after familiarisation with the digital interface, participants were asked to complete the PD. Each participant was instructed verbally by an operator on how to complete PDs using a digital tablet. The following question was asked: "Please shade on this body chart using the stylus pen where you felt your usual pain during the last week. Try to be precise and colour every part of the body, independently from type and intensity of pain". Two trained operators, each with one tablet, participated in the study and applied a protocol described in a previous work.[37] The session's procedures including both the self-report questionnaires and the PD acquisition required approximately 20 minutes.

2.4. Data analysis

Distribution of the data was tested with the Shapiro-Wilk test and non-normally distributed data were observed; therefore, non-parametric tests have been employed for data analysis, as reported below. Descriptive statistics were used to investigate musicians' features (i.e. age, BMI, practice hours, pain extent, pain intensity, Q-Dash score and Q-Dash score optional).

The data were presented according to three different categories: Symmetric Playing Position (SPP, n=56), Asymmetric Playing Position (APP, n=78), and Voice (n=24). Instruments were allocated to SPP and APP categories according to the classification proposed by Wahlström-Edling and Fjellman-Wiklund[49]: SPP included bassoon, clarinet, oboe, percussion, piano/organ, trumpet and APP included cello, double bass, flute, guitar, trombone, violin, viola (see Discussion for further information on and justification of Wahlström-Edling and Fjellman-Wiklund's classification).

Using a software developed and evaluated in previous works,[36,37] the following PDs analysis were completed:

- *Pain extent:* each pair of PDs completed (i.e. frontal and dorsal) by the same musician was processed to quantify the total number of pixels coloured inside the frontal and dorsal body charts. The pain extent was expressed as the percentage of the total body chart area.
- *Pain frequency maps:* all PDs were overlaid and analysed simultaneously to indicate the most frequently reported location of pain across the entire sample. A colour grid was used to illustrate the percentage of musicians that reported pain in a specific area. This was computed for the frontal and the dorsal body charts, and for women and men separately.
- *Pain location:* the body charts were divided into anatomical regions according to the Margolis rating,[45] and the percentage of musicians reporting pain in specific body regions was presented using histograms.

The Wilcoxon rank-sum test was used to verify if the value of pain extent (expressed as a percentage) significantly changed according to sex. Spearman's correlation coefficients were computed to reveal possible associations between pain extent and musicians' features (i.e. age. BMI, practice hours, pain intensity, QD Disability score, and score on the QD optional module for performing artists). The Wilcoxon rank-sum test was used to test for differences in continuous variables (i.e. age, BMI, practice hours, pain intensity, QD Disability score, and score of the QD optional module for performing artists) in musicians with and without pain. Hypothesis tests with significance level α=0.05 were used to identify significant correlations between observed variables. As several tests were performed, Bonferroni correction for multiple testing has been applied.

Heat maps were generated to allow the visual comparison of pain frequency in different Margolis regions and for different groups of musicians. Frequency was computed as:

$$\frac{n_1 + s/2}{n + s}$$

where n is the total number of musicians in a group, n_1 is the number of those reporting pain, and $s = 1$ is a smoothing parameter correcting for small samples. The height of the rows in the heat maps is proportional to the size of each group of musicians.

All statistical analyses were carried out using the R language and environment for statistical computing (R Core Team 2015; R: A language and environment for statistical computing, R Foundation for Statistical Computing, Vienna, Austria; https://www.R-project.org.).

3. Results

Descriptive statistics

Table 1 shows descriptive features of the participants including age, BMI, practice hours, pain intensity, QD Disability score, and score on the QD optional module for performing artists, as well as pain extent. They are listed according to their playing posture and divided by sex. Following Wahlström-Edling and Fjellman-Wiklund[49], instruments classified as Symmetric Playing Position (SPP; n=56) included bassoon (n=4), clarinet (n=9), oboe (n=6), percussion (n=4), piano/organ (n=24), trumpet (n=9). Those classified as Asymmetric Playing Position

(APP; n=78) included cello (n=13), double bass (n=5), flute (n=12), guitar (n=6), trombone (n=5), violin (n=25), and viola (n=12). There were also 24 singers classified into a separate Voice category.

[INSERT TABLE 1 ABOUT HERE]

Of the 158 musicians participating in the study, 126 (79.7%) reported having pain in at least one Margolis anatomical region. Only 32 people (20.3%) reported having no pain. Musicians with SPP and musicians with APP reported a similarly high number of complaints in at least one Margolis anatomical region, with a prevalence of 75% and 78.2% respectively (see Figure 2). On the other hand, singers reported the highest prevalence of complaints (95.8%), with 23 out of 24 reporting pain in at least one Margolis anatomical region. The mean of pain extent was 3.1% ±6.5.

[INSERT FIGURE 2 ABOUT HERE]

PDs analyses

Figure 3 illustrates the pain frequency maps for the full sample included in the study, whereas Figures 4 and 5 illustrate the pain location, where the perceived painful regions of the body for women and men for the frontal view (Figure 4) and dorsal view (Figure 5) of the body are reported.

[INSERT FIGURE 3 ABOUT HERE]

[INSERT FIGURE 4 ABOUT HERE]

[INSERT FIGURE 5 ABOUT HERE]

The Wilcoxon rank-sum test was run to determine if there were differences in pain extent between women and men. Distributions of pain extent for women and men were similar, as assessed by visual inspection. The results reported no statistical evidence of a relationship between pain extent and sex, and the pain extent was not significantly different between men and women.

Correlational analyses

The results of the correlational analyses between pain extent and musicians' features (i.e. age, BMI, practice hours, pain intensity, QD Disability score, and score on the QD optional module for performing artists) are reported in Table 2.

[INSERT TABLE 2 ABOUT HERE]

The Spearman correlation test to assess the relationship between the feature variables (i.e. age, BMI, practice hours, pain intensity, QD Disability score, and optional QD performing arts module score and pain extent showed no evidence of a relationship between age and pain extent, BMI and pain extent, nor practice hours and pain extent. Conversely, there was a significant positive correlation between pain extent and pain intensity ($p \leq 0.001$). Furthermore, both the QD Disability score and optional QD performing arts score increased with greater pain extent ($p \leq 0.001$).

The age of individuals reporting pain was significantly higher than the age of individuals not reporting pain ($p=0.016 < 0.01$). However, the p-value cannot be considered significant using

Bonferroni's correction for multiple comparisons (p-value < 0.05/12= 0.0042), even though it is below the significance level of 0.05.

There was no statistical relationship between BMI and the presence of pain. However, the mean number of practice hours was significantly lower for people with pain (p= 0.002); similarly, the mean of both the QD Disability score and the optional QD performing arts module score was higher for musicians reporting pain, than for musicians without pain (p < 0.001).

Heat map

A heat map was generated to represent graphically the pain location among the three different groups: SPP, APP, and Voice. The different colors correspond to the level of the measurement, with dark red representing the most frequently reported pain location. As seen in Figure 6, the heat map revealed that the neck and shoulder regions and, to a lesser extent, the area of the lower back, were the most frequently affected areas.

[INSERT FIGURE 6 ABOUT HERE]

4. Discussion

This study examined performance related pain among musicians using analyses of a digital method for illustrating the location and the extent of pain.

All participants were able to complete their PD. Regarding the drawing experience, participants revealed some degree of easiness in the ability to reproduce their pain. In addition, they did not experience difficulties in identifying with the body chart and the distinction of gender body charts was considered extremely important because it allowed a more accurate and individual expression of their pain.

With respect to the researchers, the applicability of digital PD during the sessions has been reported to be high. Currently, paper body chart has been used to detect the location of pain. In this study, we sought to include both location and extent of pain, which could be more problematic if using the traditional paper body chart. Furthermore, by using tablets connected to computers to process participants' records, it is possibly to storage data in a more effective and accurate way. Therefore, the assessment of the location and the extent of pain is easy for the participants and offers a more reliable and operative instrument for health care practitioners and researchers.

These findings are consistent with previous studies showing that the lifetime prevalence of musculoskeletal problems in musicians typically exceeds 50%, in most reports ranging between 62% to 93%.[4,17,31]

The observed pain extent in our sample was 3.1%. Previous studies, that applied the same digital pain drawings method, reported higher values of pain extent in patients with low back pain and whiplash.[37,38] This difference may be expected as both the populations included patients with chronic pain in which expanded areas of pain and widespread pain are common. The individual pain drawings revealed large variability between participants yet collectively, as seen from the pain frequency maps presented in Figure 3, their reports of pain covered almost the entire upper part of the body (especially the dorsal part). Both the frontal and dorsal pain frequency maps clearly indicate that the neck and shoulder regions, and to a lesser extent, the lower back, were the most frequently affected areas. In contrast, substantially fewer people reported pain in their pectoral and abdomen regions, although there was pain here for some musicians. A similar picture is provided by other studies that have investigated pain in musicians, where the regions with the highest prevalence of musculoskeletal symptoms the shoulders, neck, and back.[4,17,29]

Recent studies showed that women are more inclined to experience pain than men.[4,17,29,50] Although there was no evidence of a relation between sex and pain extent, the pain location analysis indicated that female musicians reported a higher occurrence of complaints than men, as illustrated in Figure 4 for the frontal aspect of the body and Figure 5 for the dorsal aspect. With regard to the frontal aspect, there is a prevalence of frequent pain in the area of the neck for both women and men, with an incidence of 27.9% and 17.0%, respectively. However, with respect to the other regions of the frontal aspect of the body, women and men presented with different locations of pain. While women reported a high prevalence of pain in the forearms and hands (e.g. 17.1% in the right forearm) compared with men (e.g. 4.8% in the right forearm), men reported more frequent pain in the chest and abdominals (i.e. 10.2% in the left chest for men versus 2.7% in the same region for women). Turning to the dorsal aspect of the body, the difference between women and men becomes more accentuated: female musicians reported a higher prevalence of complaints than men, especially in the neck (47.7%), the right shoulder (39.6%), the left shoulder (32.4%) and the lower back (32.4% on the right and 31.5% on the left). Male musicians reported less pain, with a maximum of 10.9% of the men reporting pain in the neck.

Musicians are typically subject to monotonous performance positions that, depending on the instrument, often involves prolonged static use of the neck and shoulders, a repetitive use of joints in the upper extremity, or a combination of both. Although there was no statistical evidence of a relation between pain extent and practice hours, the mean number of practice hours was lower for people reporting pain in at least one Margolis area, suggesting that those with pain were less able to practice for long periods of time. At length, a daily practice routine accompanied by straining and repetitive movements can even degenerate into chronic health problems that may affect musicians irreparably. Many studies have shown that about 12% of musicians abandon their musical careers due to such problems[1,51]. Regarding age, our study revealed no evidence of a relation between age and pain extent. While comparison between the age of individuals reporting pain in at least one Margolis region and that of individuals not reporting pain (although not significant considering the number of tests performed) leaves room to the hypothesis that the former is higher than the latter as it produces a p-value as low as 0.016. This could be attributed to the fact that a possible alteration of anthropometric characteristics could be developed after several years of practice. For example, the hand span or even the posture itself could be modified due to continuous stretching of ligaments, tendons and muscles. Moreover, it has been demonstrated that the risk factors for the development of pain in musicians include: (a) physical factors of the individual such as age, sex, anatomical individualities (i.e. joint laxity, arm and hand size), physical condition, and muscle conditioning and (b) music-related factors such as technique, posture while practicing, support of the instrument, duration of practice, change of instrument, playing time and intensity, and the repertoire itself.[9,51,52]

Considering the extreme physical demands of performance, musicians can be seen as athletes of the upper body. Investigations among musicians have revealed a differences between the instrumental groups in this respect and have demonstrated, for instance, that string players are more likely to experience pain than woodwind players.[4,14,23,50]

Several instruments, such as the flute, guitar, violin and viola, oblige the musician to adopt asymmetric playing positions.[49,50] With these instruments, players are required to elevate one or both arms, which in turn demand a constant static work of the muscles to steady the scapula and shoulder joint. Furthermore, they are required to rotate and turn the head, or keep an asymmetric posture with their lower back rotated to one side. In the meantime, repetitive movements with the arms and fingers are normally performed with a constant interaction between rapidity and precision.[49] Other instruments conversely, such as the clarinet, oboe and piano, require a more symmetric playing positions with both arms nearby the body and the head straight. However, in order to play these instruments, a static and repetitive load on the arms and neck-shoulder muscles are still necessary.[4,49]

In order to analyse differences in terms of pain prevalence among different instrumental groups, we used the classification of symmetry and asymmetry according to Wahlström-Edling, & Wicklund's study of musculoskeletal disorders and playing postures among music teachers.[49] We employed an additional category for Voice, due to the specific characteristics of their musical practice. Interestingly, our results showed the highest prevalence of pain among the three groups. This finding may be attributed to the fact that singers may experience an overuse of the vocal tract, and have to stand in static positions for long periods during both rehearsal and performance.

Nonetheless, when we take into account the distribution of pain in the various Margolis anatomic regions among the three groups (see Figure 6), the prevalence of pain in the neck, shoulders and lower back was consistently high among all three groups. It is indeed remarkable that the majority of musicians seems a homogenous group in terms of pain location.

Regarding the pain extent, it should be noted that the highest value has been reported by musicians with an APP (3.5%), which has been previously confirmed by other studies regarding the matter of asymmetry of musicians' playing position[4,49]. Asymmetry of body position, which is a recognised issue in ergonomics for biomechanical risk assessments[29], involves playing with one or both arms elevated. Previous studies have shown that working with elevated arms could lead to muscle and tendons degeneration, which produces pain and distress.[49,53-56]

Clinical implications

In sum, singers and instrumentalists had a high and equally distributed frequency of pain, although singers reported a higher prevalence of symptoms than instrumentalists. This results could be employed to develop interventions of prevention initiatives for advanced musicians. These initiatives could consist of exercises tailored to specific body areas (namely, the neck, shoulders and lower back) and generic exercises to enhance neuromuscular control to prevent pain, especially since low levels of physical conditioning and lack of exercise probably contribute to the appearance of musculoskeletal disorders in musicians[2]. We can speculate that the lack of proper physical conditioning may play an important role in high prevalence of pain observed in this study, and much needs to be done to prevent musicians from experiencing ongoing pain and disability.

Methodological considerations

To the best of our knowledge, our study is the first that used a digital platform to assess pain location and extent in musicians with reported upper quadrant complaint. The method proposed in the study represents an effort to optimize previous methods (i.e. paper body chart) investigating pain among musicians.[11] PDs can be obtained directly from the patient, without any intervention from an investigator, which likely improves the quality and the accuracy of the PD completion. The software used to evaluate the extent and location of pain removes estimation errors (i.e. it is a deterministic system in which no randomness is involved) which possibly occur with visual-subjective scoring methods.[37,38,45] Moreover, the use of pixels allows to estimate accurately the pain extent.

Finally, the method described in this study enables quantitative data to be extracted from the PDs, which can be in turn be analysed statistically.

However, although we had a relatively large sample size, it was not possible to find significant differences between the three groups (i.e. SPP, APP, Voice). It could be hypothesized that with a larger population in each group, other correlations could be found and more analyses could have been conducted.

Additionally, psychological measures were not included in this study. However, it may be relevant in future studies to evaluate the association between pain reported in the digital PDs and psychological measures, in order to gain greater insight into the causes and personal significance of pain among musicians. A recent study on patients with whiplash associated disorders supported this approach and revealed that pain drawing may be part of the psychological screening of patients with chronic painful conditions.[38]

Furthermore, future studies should examine whether the findings reported here are reproducible at a different playing level, including among concert soloists and professional orchestral players.

Limitations

There are two limitations to be aware of when considering the reported findings. Firstly, PRMD is a collective term encompassing pain and several other distressing symptoms such as weakness, numbness, tingling, or other physical symptoms that affect the ability to play an instrument. In this study, we focused on pain, as a main and specific complaint of PRMDs. A more comprehensive investigation considering other symptoms related to PRMDs may yield to different results enlightening the relevance of such symptoms in PRDM.

Secondly, it is important to acknowledge that the evidence point out that conscious sense of our body (i.e. the body image) and tactile acuity can be distorted in people with chronic painful conditions

(PMID: 18786763, PMID: 18177603). Although, the relationship between the distortion of the body image and the capacity to draw the pain experience on a body chart has never been investigated, it is reasonable to hypothesize that this condition may reduce the accuracy and the precision of the PD.

5. Conclusion

The high prevalence of pain among musicians has been confirmed using digital PDs.

In addition, positive correlation between pain extent and upper limb disability has been demonstrated.

Our findings highlight the need for effective prevention and treatment strategies for musicians.

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Descriptive statistics

Variables	*Median (IQR)*			
	SPP	**APP**	**Voice**	**Total**
Age (years)	**21 (5)** f=21 (6) m=21 (5)	**22 (6)** f=22 (6) m=22 (6)	**23 (4)** f=23 (4) m=25 (18)	**22 (5.3)** f=22 (6) m=22 (5)
BMI	**22 (5)** f=25.3 (7) m=22.3 (3)	**23.5 (7)** f=24.1 (7) m=21.7 (5)	**23.8 (4.3)** f=24.3 (5) m=23.4 (4)	**23.2 (6.1)** f=24.4 (7) m=22 (4.3)
Practising (hours)	**29.5 (15)** f=28 (23) m=31 (12)	**32.3 (19)** f=30 (24) m=34.5 (17)	**11.7 (16.1)** f=11.5 (16) m=19.4 (18)	**30.6 (16.2)** f=30 (23.6) m=32 (14)
Pain extent (%)	**2.8 (7)** f=3.3 (12) m=2.3 (6)	**3.5 (6)** f=3.7 (6) m=2.4 (6)	**2.2 (3.2)** f=2.4 (3) m=1.2 (5)	**3.1 (6.5)** f=3.6 (8) m=2.3 (6.3)
Pain intensity (1-5)	**1 (1)** f=2 (2) m=1 (1)	**1 (1)** f= 1 (1) m=1 (1)	**n/a**	**1 (1)** f=1 (1) m=1 (1)
Q-dash score (0-100)	**5.7 (13)** f= 9.1 (15) m=2.3 (11)	**2.3 (9)** f=2.3 (11) m=0 (6)	**n/a**	**2.3 (9.1)** f=4.6 (11.4) m= 1.1 (6.8)
Q-dash score optional (0-100)	**0 (30)** f=0 (31) m=0 (25)	**0 (13)** f=0 (16) m=0 (13)	**n/a**	**0 (19)** f=0 (20.3) m=0 (19)

[1]

---

[1] **Table 1. Descriptive statistics**

Participants' features (age, BMI, practice hours) and clinical variables (pain intensity, Quick DASH Disability score, score on the Quick DASH optional module for performing artists, and pain extent percentage). Values are expressed as medians and interquartile ranges, reported according to their playing position (Symmetric Playing Position, SPP n=56; Asymmetric Playing Position, APP n = 78; Voice n = 24), and divided by sex.

Correlation with pain extent

		r_s	p-value	S
	Age	-.038	.319	682090
	BMI	.068	.198	612590
	Practice hours	-.025	.379	673600
Pain	Pain intensity	.380	≤ 0.001 ***	407840
Quick Dash	QD Disability score	.459	≤ 0.001 ***	355520
	QD optional module score (module for performing artists)	.424	≤ 0.001 ***	378600

[2]

[2] **Table 2. Correlation with pain extent**

Spearman's correlation coefficients between the pain extent computed from the pain drawings and musicians' features.

Wilcoxon rank-sum test: musicians with pain vs musicians without pain

		p-value	W
	Gender	.061	3499
	Age	.016	2511.5
	BMI	.134	2272.5
	Practice hours	.002 ***	2700.5
Pain	Pain intensity	n/a	n/a
Quick Dash	QD Disability score	<.001 ***	1219
	QD optional module score (module for performing artists)	<.001 ***	1317.5

[3]

[3] **Table 3. Wilcoxon rank-sum test: musicians with pain vs musicians without pain**

Results of the relationship between all variables and pain presence in at least one Margolis region.

Figure 1

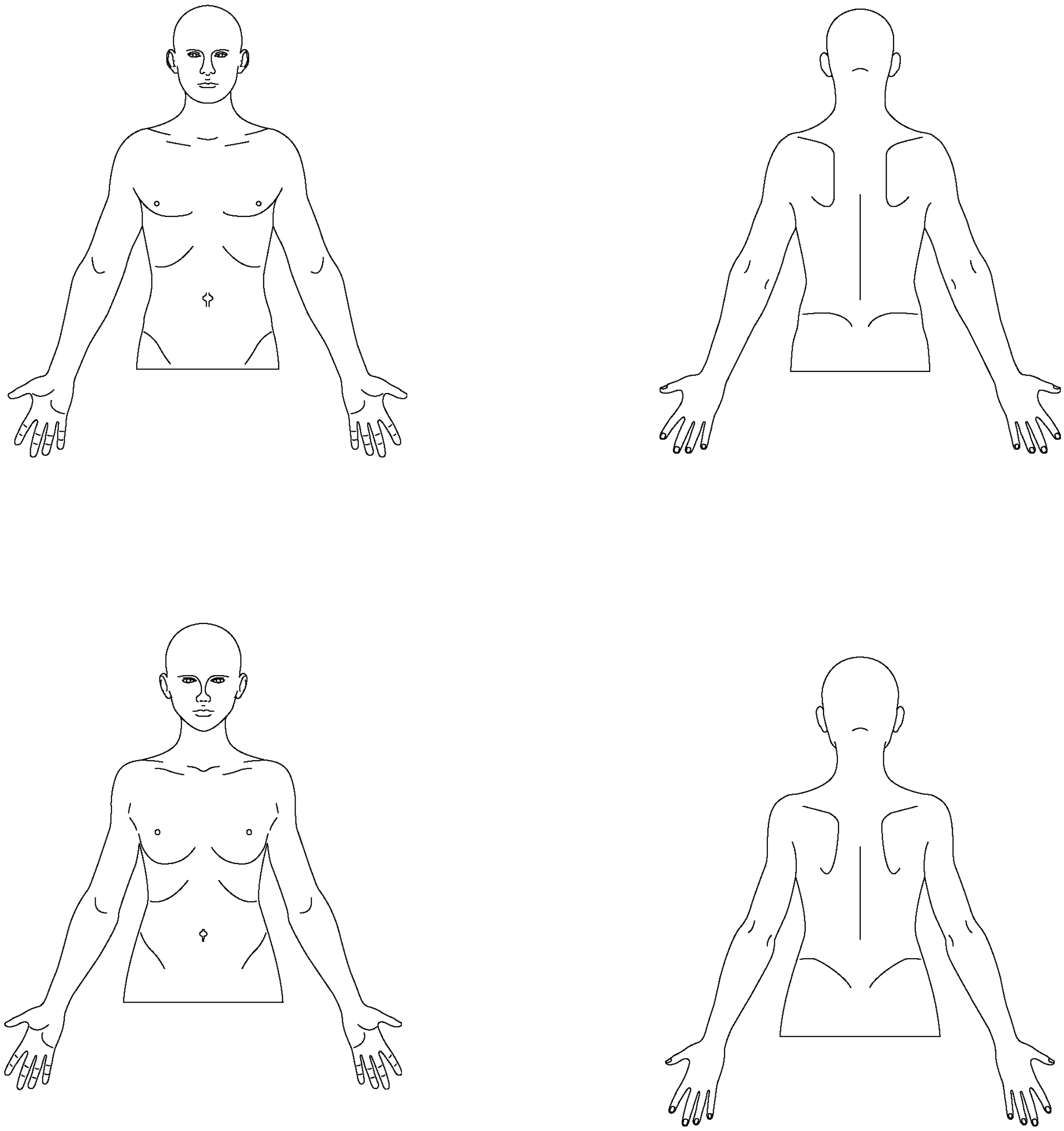


Figure 2

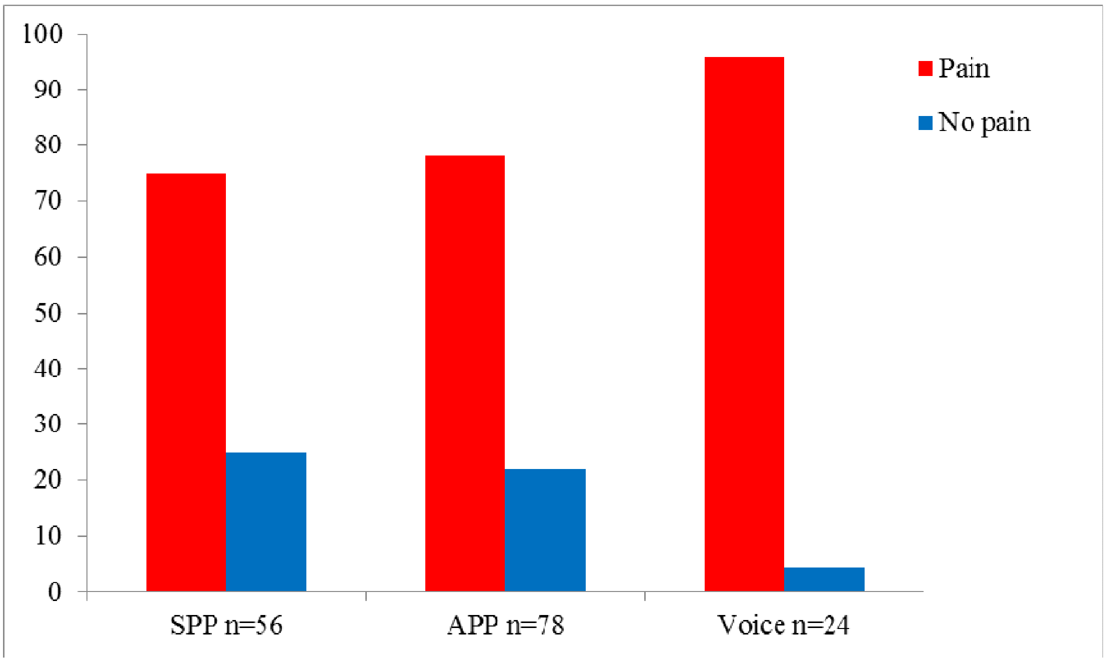
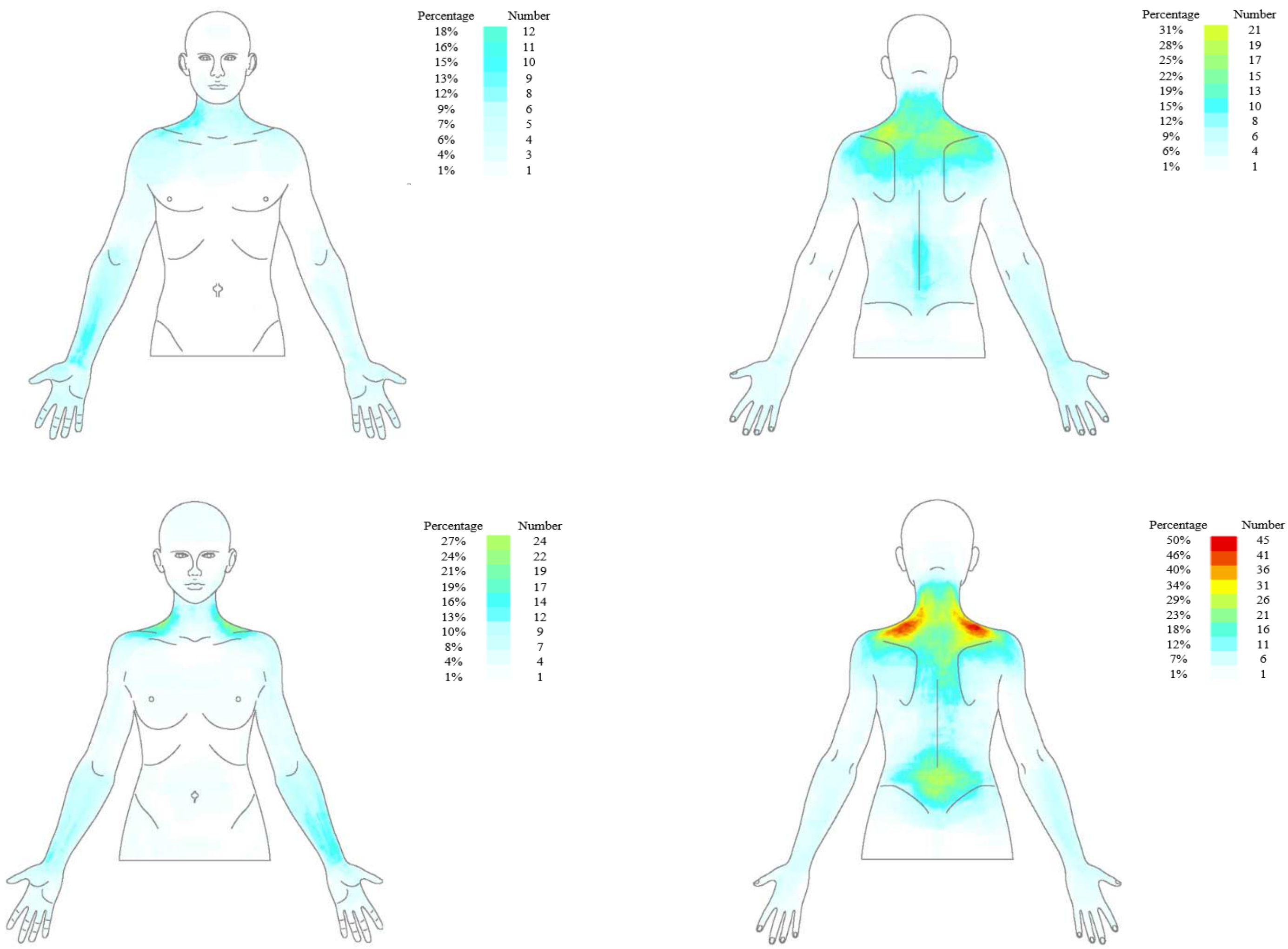

100
90
80
70
60
50
40
30
20
10
0
Pain
No pain
SPP n=56
APP n=78
Voice n=24

Figure 3



Percentage Number
18% 12
16% 11
15% 10
13% 9
12% 8
9% 6
7% 5
6% 4
4% 3
1% 1
Percentage Number
31% 21
28% 19
25% 17
22% 15
19% 13
15% 10
12% 8
9% 6
6% 4
1% 1
Percentage Number
27% 24
24% 22
21% 19
19% 17
16% 14
13% 12
10% 9
8% 7
4% 4
1% 1
Percentage Number
50% 45
46% 41
40% 36
34% 31
29% 26
23% 21
18% 16
12% 11
7% 6
1% 1

Figure 4

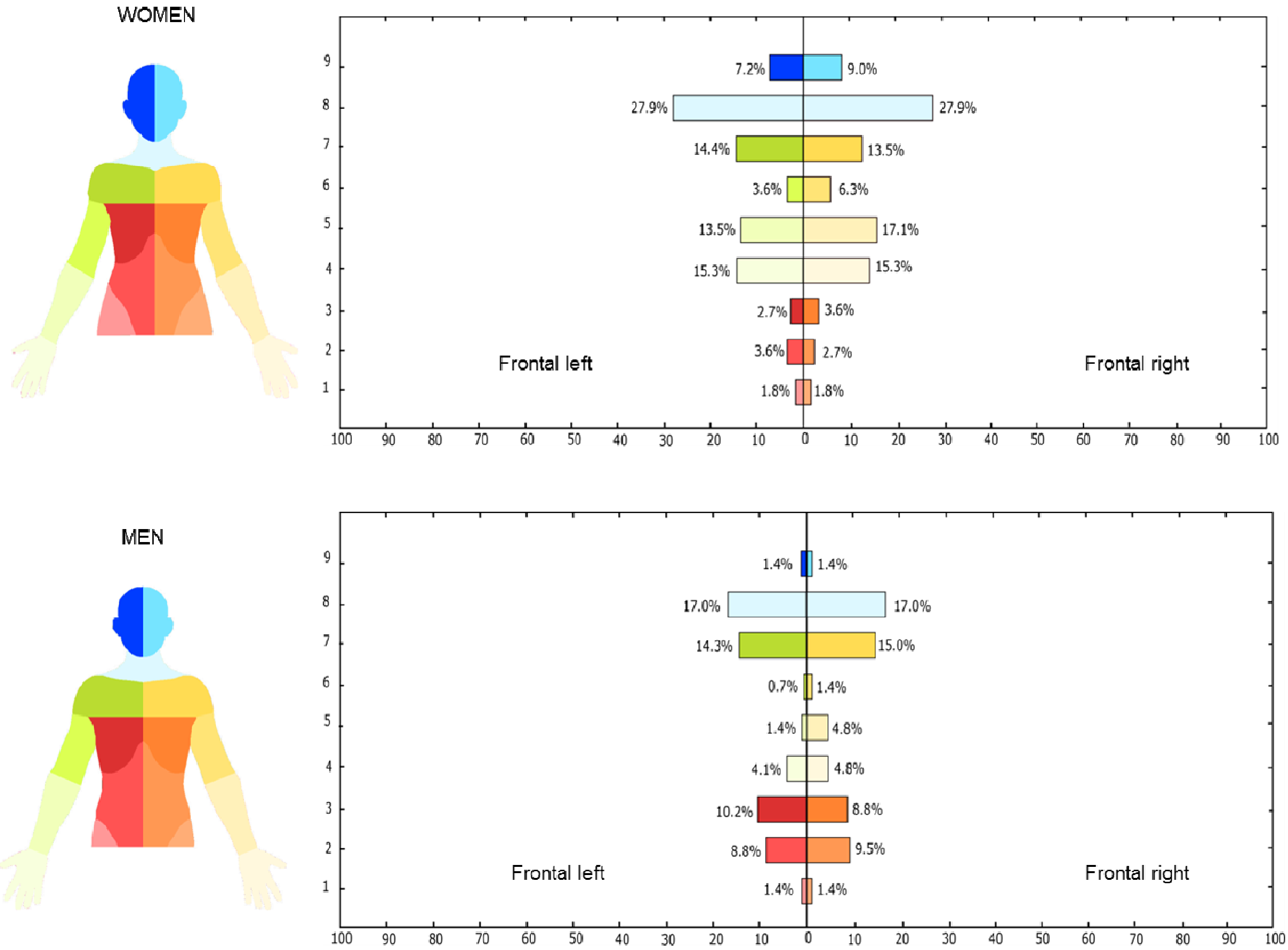
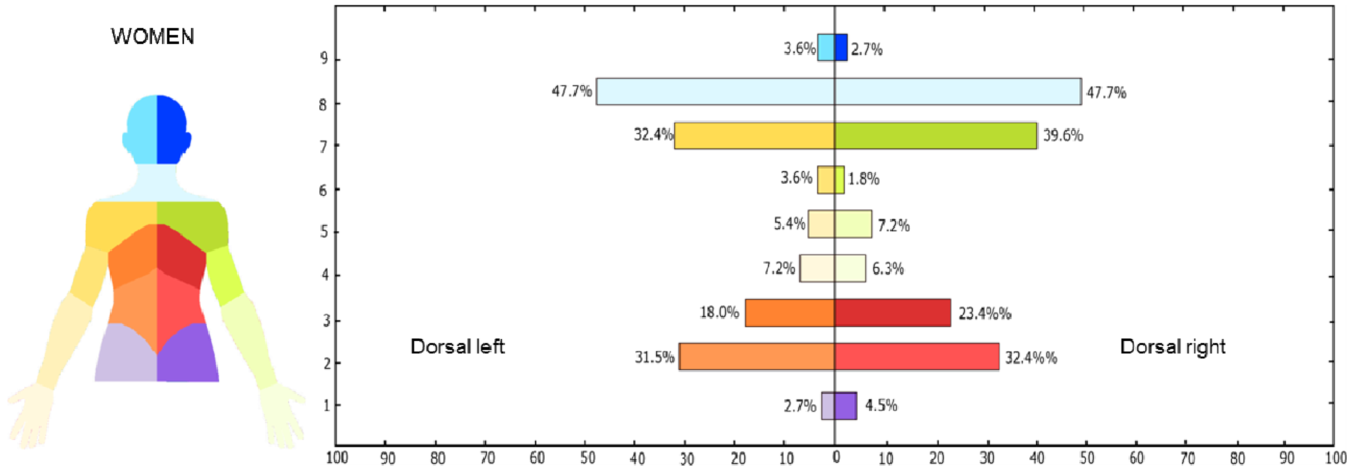

WOMEN
7.2%
9.0%
27.9%
27.9%
14.4%
13.5%
3.6%
6.3%
13.5%
17.1%
15.3%
15.3%
2.7%
3.6%
3.6%
2.7%
1.8%
1.8%
Frontal left
Frontal right
MEN
1.4%
1.4%
17.0%
17.0%
14.3%
15.0%
0.7%
1.4%
1.4%
4.8%
4.1%
4.8%
10.2%
8.8%
8.8%
9.5%
1.4%
1.4%
Frontal left
Frontal right

Figure 5


WOMEN
Dorsal left
Dorsal right
3.6%
2.7%
47.7%
47.7%
32.4%
39.6%
3.6%
1.8%
5.4%
7.2%
7.2%
6.3%
18.0%
23.4%%
31.5%
32.4%%
2.7%
4.5%

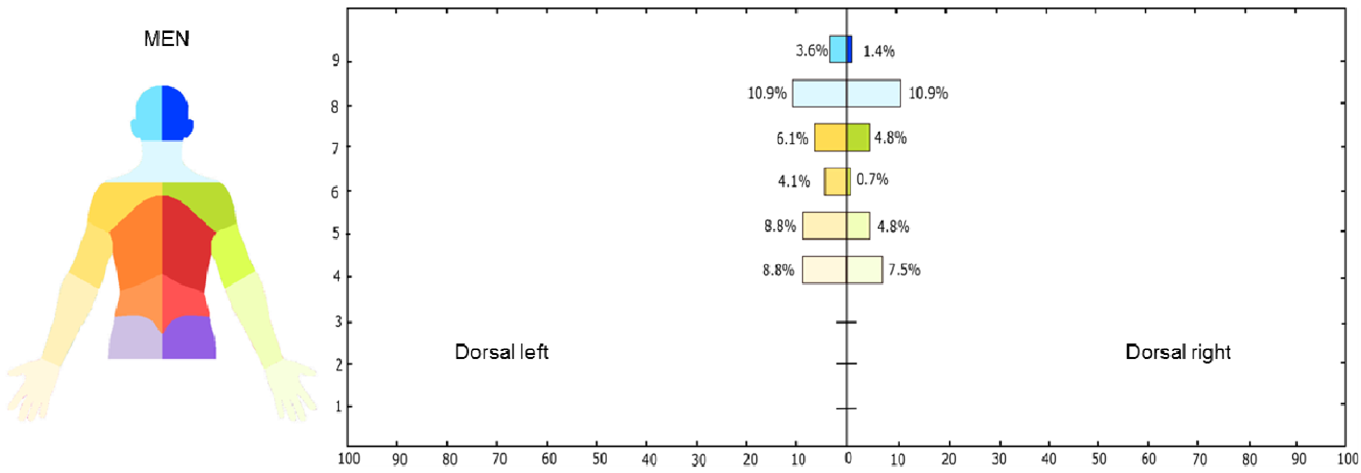
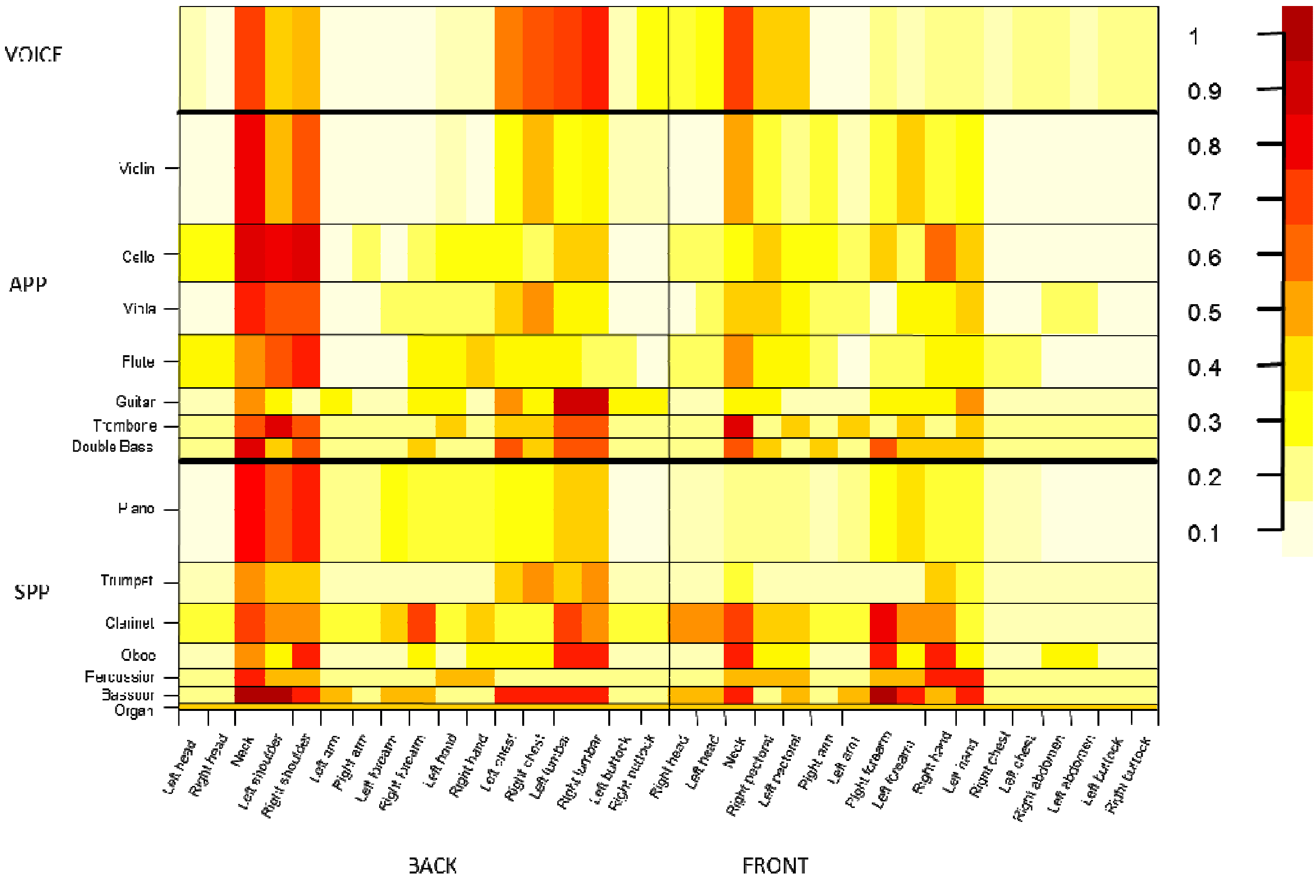

MEN
Dorsal left
Dorsal right
3.6%
1.4%
10.9%
10.9%
6.1%
4.8%
4.1%
0.7%
8.8%
4.8%
8.8%
7.5%

Figure 6


VOICE
APP
SPP
Violin
Cello
Viola
Flute
Guitar
Trombone
Double Bass
Piano
Trumpet
Clarinet
Oboe
Percussion
Bassoon
Organ
Left head
Right head
Neck
Left shoulder
Right shoulder
Left arm
Right arm
Left forearm
Right forearm
Left hand
Right hand
Left chest
Right chest
Left lumbar
Right lumbar
Left buttock
Right buttock
Right head
Left head
Neck
Right pectoral
Left pectoral
Right arm
Left arm
Right forearm
Left forearm
Right hand
Left hand
Right chest
Left chest
Right abdomen
Left abdomen
Left buttock
Right buttock
BACK
FRONT
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1