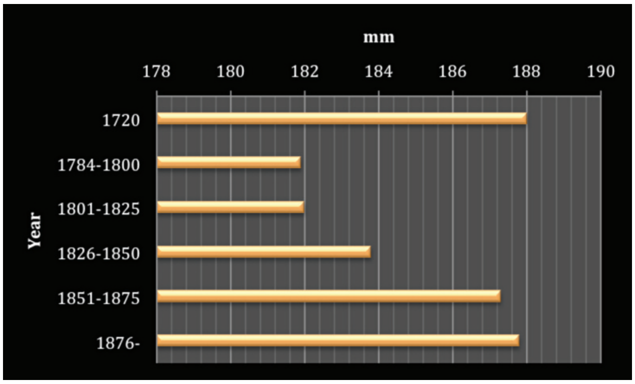
The Application Of An Ergonomically Modified Keyboard

To Reduce Piano-Related Pain

By Eri Yoshimura and Kris Chesky

The key width for the modern piano was established about 130 years ago. Before then, the key widths varied and were typically narrower than the modern piano as shown in Figure 1. During these early years it would have been normal for pianists to play and compose on different sizes of keyboards. In fact, technically challenging pieces written between 1750 and 1850 were probably composed using pianos with narrower keys underscoring Sakai's rationale as to why many modern pianists struggle with difficult piano techniques on a modern piano.[1] Since the distance of an octave span became fixed around 1880, pianists have been dealing with the idea of a one-size-fits-all piano and the disappearance of optional key widths for the piano.

Figure 1: *Average octave span of 75 historical pianos*[2]



Some may argue that different-sized keyboards are unnecessary. However, the normal range of hand sizes is substantial, and there are many small-handed pianists including women and children. To illustrate, Figure 2 shows hand span data from about 400 students measured at the University of North Texas. The difference in span between the smallest hands to the largest is about 11 cm, or a little more than 4 inches. This difference is close to the width of five piano keys. As shown in Figure 3, it is obvious that the larger hand (span = 246 mm) shown in this photo fits the key width of this modern piano better than the smaller hand (span = 185 mm).

Figure 2: *Right hand span of 397 students and pianists*

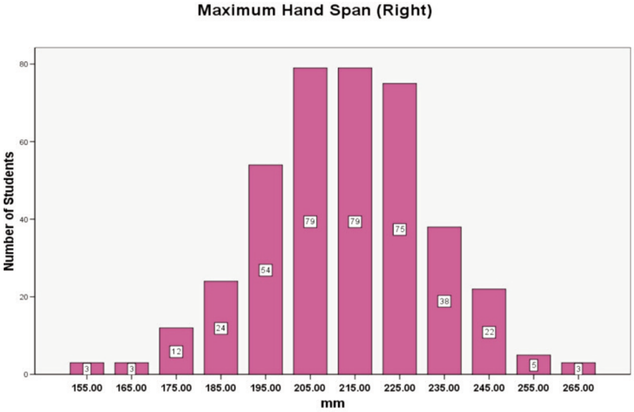
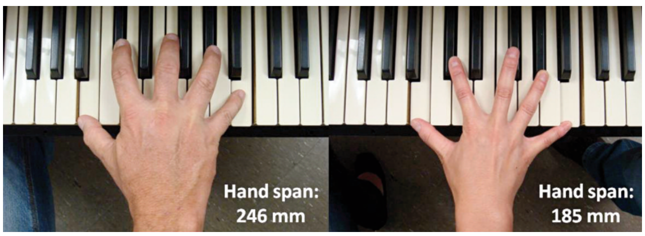


Figure 3: *Right hand playing a chord (B-C#-G#-B) on the modern keyboard*



What makes this discussion serious, urgent and, possibly ethical, is the fact that small-handed pianists are clearly at a disadvantage to perform certain literature and likely to experience pain because of mismatches between hand size and key width. These types of problems are not exclusive to the piano or pianist. However, they are often addressed through principles of ergonomics, or the concept of fitting tools or workspaces to human anthropometric indices. Ergonomics is a universal and widely accepted safety and health practice that is used throughout the world to minimize occupational injuries.[3,4,5]

In addition to the logical conclusion that one might draw from observing small-handed pianists at the piano, research studies provide evidence that hand size is a crucial risk factor for pain and subsequent injury.[6,7] Two recent studies by the authors of this paper reported that 86 percent of 35 piano majors at the University of North Texas and 91 percent of 47 piano teachers attending a Music Teachers National Assoication conference experience pain while playing the piano.[8,9] Both studies reported significant negative correlations between hand size and pain. Reports of higher prevalence for playing-related pain among females also support this relationship because female hands are generally smaller than those of men.[10]

Despite calls by some pianists and instructors to consider and adopt the use of modified keyboards for small-handed pianists based on the principles of ergonomics,[11,12,13] the key width of the vast majority of pianos used today conform to the so-called "standard" size of 188 mm per octave. Some manufacturers like Yamaha (Japan) and Steinbuhler (Titusville, Pennsylvania) have built and sold narrower-sized keyboards. Yamaha stopped making these keyboards in 2003 due to the lack of demand after 14 years of production. Steinbuhler offers keyboards that can be temporarily or permanently placed into any piano.

At UNT, we offer students the practice pianos with permanently modified keyboards and the option for modifying the key width of our concert grand pianos to be used during formal recitals and concerts. As we routinely witness the profound significance associated with providing these options, we also realize that UNT is one of only a few music schools in the United States embracing this concept and offering these resources to students. Attempting to explain or rationalize why these options are not widely adopted by other major music schools in the United States is beyond the scope of this paper. One reason might be the lack of research studies documenting the effect of modified keyboards on performance-related pain. To address this lack of supporting evidence, the purpose of this study was to assess the effectiveness of an ergonomically modified keyboard for alleviating playing-related pain.

Methods

Procedure

College students majoring in piano were recruited to participate in this study. After signing an approved Institutional Review Board consent form, each subject was given instructions for participation, a copy of musical repertoire to be used during the study and a schedule with performance dates and times. The schedule consisted of a two-week time frame to practice the assigned repertoire that included 45 minutes of access to a piano with a 174-mm keyboard. Following the two-week period, subjects performed the assigned repertoire on two consecutive days and two different pianos. One of the two pianos was fitted with a 174-mm keyboard, and the order of piano used was randomly determined. All performances were video recorded (Sony DCR-TRV18 camcorder) from a fixed position directly above the keyboard. Immediately before and following both performance requirements, subjects responded to questions listed on an assessment questionnaire.

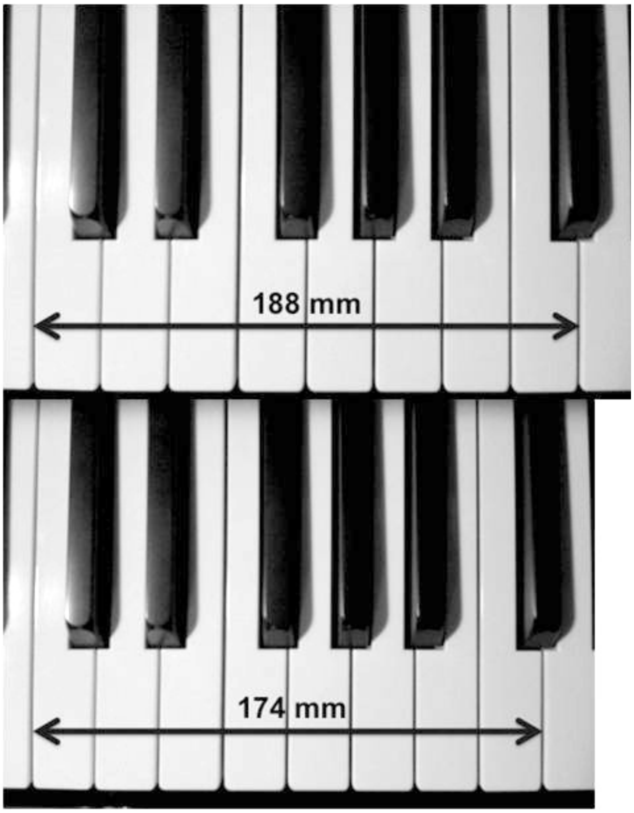
Repertoire

The assigned repertoire consisted of three sections. The first section included ascending and descending octave scales in C major played with 8th notes, 16th notes and then sextuplets, first performed at dynamic level piano and then at forte. The second section included ascending and descending chord scales in C major played with 8th notes, 16th notes and then sextuplets, first performed at dynamic level piano and then at forte. The metronome marking for the first two sections was presented as quarter note = 60. The third section included a one-page excerpt from *L'Isle Joyeuse* by Claude Debussy (Measure 220–243; Publisher: G. Henle Verlag Urtext).

Pianos

Two grand pianos (Steinway, Model L) were used for this study. One of the two pianos was fitted with a 174-mm keyboard (15/16 – Universal model, Steinbuhler & Company: Titusville, Pennsylvania). The difference between the two keyboards is shown in Figure 4. All set ups, tunings and modifications of the pianos were conducted by a full-time piano technician working for the university. The pianos were placed side by side in the same room to minimize differences in the acoustical surroundings.

Figure 4: *Octave Span of the Standard-sized Keyboard (Top) and the Ergonomically Modified Keyboard (Bottom)*



Measures

In addition to basic demographic, anthropometric and musical background information, 10-cm Visual Analogue Scales (VAS) were employed to determine levels of pre- and post-performance pain. Pain and tension while playing were also measured following each performance using VAS scales. After the second performance, subjects were asked, "If you were given a choice, which keyboard would you prefer to use? And why?"

Overview Of Data Analyses

We examined the hypothesized associations between pain related to playing the piano, keyboard size and hand span. First, we compared (paired t-test) the pre-performance pain levels across the keyboard conditions for the whole group to control for any differences in pain reported before performing. Secondly, we calculated the changes in pain by subtracting the pre-performance pain scores from the post-performance pain scores. Paired t-tests were used to determine whether the changes (difference scores) in pain were different across the two performance conditions (174-mm versus 188-mm keyboard). The same test was utilized to report differences in the post-performance pain and the pain and tension while playing across the two keyboards. Thirdly, Pearson correlation coefficients were used to examine the relationships between pain and hand span. To further explore the influence of hand span, the subject group was split into two sub-groups across the average (mean) hand span of the whole group. Unpaired t-tests, correlations and scatter plots were used to examine differences of the pain and tension while playing (assessed following performance) across keyboards within these two groups.

Video Observation

The still images of subjects' hands were captured from the video files using the Image Capture software. The selected frame for observation was the moment when the subjects played a chord (B-C#-G#-B) from Debussy's *L'isle joyeuse* (Figure 5). First, the largest and smallest hands among the subjects were compared when playing on the 188-mm keyboard. Secondly, angles of fingers 2 and 4 were measured to evaluate the difference across keyboards of the small hands. Thirdly, two images of the same hands playing on the 188-mm and the 174-mm keyboards were outlined and then stacked in order to observe differences in posture.

Figure 5: *Chord (B-C#-G#-B) from Debussy's* L'isle joyeuse

Results

Subjects

A convenience sample of 35 piano major students at the University of North Texas agreed to participate in this study. Table 1 and Table 2 describe demographic and anthropometric data of this subject population. These data were also reported in a previous paper.[14]

Table 1: *Descriptive Demographic and Music Background Data*

	Frequency		Percent	
Males	8		22.9	
Females	27		77.1	
Single	29		82.9	
Married	6		17.1	
Caucasian	14		40.0	
Asian	20		57.1	
Hispanic	1		2.9	
	Minimum	Maximum	Mean	Std. Deviation
Age	21	41	27.17	4.99
Number of Children	0	2	0.11	0.40
Average amount of sleep	4	9	7.24	0.97
Average amount of exercise	0	7	2.00	2.07
Average travel (days/month)	0	25	2.91	4.59
Age started piano	3	13	6.04	2.30
Years of private lessons	7.5	30	19.37	5.21
Years of college piano	2	20	7.33	4.27
Size of hands (Subjective)*	0.10	10	4.78	2.51

*Subjects answered on VAS

Table 2: *Anthropometric Measures of Upper-extremity*

Variable	Minimum	Maximum	Mean	Standard Deviation
Height (cm)	147.0	188.0	164.09	9.81
Weight (kg)	40.0	83.0	58.27	11.77
Left upper arm length (mm)	260	350	298.74	22.18
Right upper arm length (mm)	260	355	299.69	23.81
Left forearm length (mm)	215	288	245.97	22.00
Right forearm length (mm)	215	287	244.20	19.17
Left hand length (mm)	148	202	174.40	13.03
Right hand length (mm)	153	203	174.86	12.51
Left wrist circumference (mm)	135	181	153.77	12.40
Right wrist circumference (mm)	140	184	154.23	12.95
Left index finger diameter (mm)	15.3	21.0	17.70	1.47
Right index finger diameter (mm)	15.9	21.3	17.98	1.46
Left hand volume (ml)	187.5	500.0	335.71	98.34
Right hand volume (ml)	187.5	562.5	352.13	97.04
Left hand span (mm)	181.0	250.0	212.43	17.73
Right hand span (mm)	183.0	250.0	209.74	17.18
Left max. interval on keyboard	8	11	9.49	0.78
Right max. interval on keyboard	8	11	9.57	0.74
BMI‡	16.12	27.46	21.50	3.02
Left thumb-index span (deg)	68	116	90.17	11.97
Right thumb-index span (deg)	64	114	87.03	10.63
Left 2-3 span (deg)	20	62	41.69	8.25
Right 2-3 span (deg)	17	54	39.17	8.03
Left 3-4 span (deg)	18	50	31.63	7.06
Right 3-4 span (deg)	10	48	29.69	8.40
Left 4-5 span (deg)	32	65	48.20	8.31
Right 4-5 span (deg)	18	64	45.49	8.59

‡ BMI = (Weight in kg / (Height in cm) x (Height in cm)) x 10,000

Statistical Analysis Of Pain Data

Subjects did report the pre-performance pain (mean = 1.18, SD = 1.79) and, as shown in Table 3, no significant difference was found between the pre-performance pains reported prior to performing on the 174-mm keyboard compared to prior to performing on the 188-mm keyboard ($t = .655$, $p > .05$).

Subtracting the pre-performance pain levels reported before performance on the 174-mm keyboard (mean = 1.09, min=0, max=7.5) from the post-performance pain levels (mean = 0.95, min=0, max=5.8) resulted in a reduction in pain of -0.13. The mean pain level reported before performance on the 188-mm keyboard was 1.27 (min=0, max=8.6), and when subtracted from the post levels (mean=1.98, min=0, max=9.2), the increase in pain was 0.71. The levels of change were significantly different ($t = 2.193$, $p < .05$) when compared across the two keyboard conditions. Confirming this finding, the reported levels of pain while playing on the 174-mm keyboard (mean = 0.96, S.D. = 1.48) were significantly less ($t = 3.001$, $p < .01$) than the reported level of pain while playing on the 188-mm keyboard (mean = 2.07, S.D. = 2.74).

Similarly, the reported levels of tension while playing on the 174-mm keyboard (mean = 2.20, S.D. = 2.54) were significantly less (t = 2.215, p < .05) than the reported levels of tension while playing on the 188-mm keyboard (mean = 3.17; S.D. = 2.92).

	188-mm keyboard			174-mm keyboard			t-value (Sig.)
	Minimum	Maximum	Mean (SD)	Minimum	Maximum	Mean (SD)	
Pre-performance pain	.00	8.60	1.27 (2.05)	.00	7.50	1.09 (1.90)	0.655 (n.s.)
Post-Performance pain	.00	9.20	1.98 (2.84)	.00	5.80	0.95 (1.48)	3.019 (p < .01)
Pain while playing	.00	8.20	2.07 (2.74)	.00	5.80	0.96 (1.48)	3.001 (p < .01)
Tension while playing	.00	9.80	3.17 (2.92)	.00	9.80	2.20 (2.54)	2.215 (p < .05)
Computed score (Subtract pre-performance pain from post-performance pain)	-4.40	8.60	0.71 (2.14)	-5.15	5.40	-0.13 (1.65)	2.193 (p < .05)

All questions were answered on VAS

Table 3: *Pain and Tension Scores*

As shown in Table 4, hand span was not significantly correlated with the pre-performance pain for either keyboard condition. However, the pain while playing on the 188-mm keyboard was significantly correlated (inverse) to left hand span (r = -.631, p < .01) and right hand span (r = -.532, p < .01). Correlations between hand span and the pain while playing on the 174-mm keyboard were lower but still significant for left hand (r = -.521, p < .01) and right hand (r = -.416, p < .01). Similar associations were observed for the tension while playing and hand span. These relationships are graphically displayed in Figures 6a and 6b to show individual pain while playing for the 188-mm keyboard and the 174-mm keyboard respectively. The negative slopes of the trend lines illustrate that hand span and pain scores are inversely correlated for both conditions. However, the slope of the regression line is less steep for the 174-mm keyboard condition meaning that the pain while playing on the 174-mm keyboard was less than the 188-mm keyboard.

Table 4: *Pearson Correlation of Hand Span and Pain/Tension*

		Left Hand Span	Right Hand Span
188-mm keyboard	Pre-performance pain	n.s.	n.s.
	Post-Performance Pain	-.577**	-.464**
	Pain while playing	-.631**	-.532**
	Tension while playing	-.556**	-.452**
174-mm keyboard	Pre-performance pain	-.278	-.212
	Post-Performance Pain	-.543**	-.421*
	Pain while playing	-.521**	-.424*
	Tension while playing	-.416*	-.352*

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Figure 6a: *Scatterplot and Regression Line of Left Hand Span (X) and Pain on the* ***188-mm*** *Keyboard (Y)*

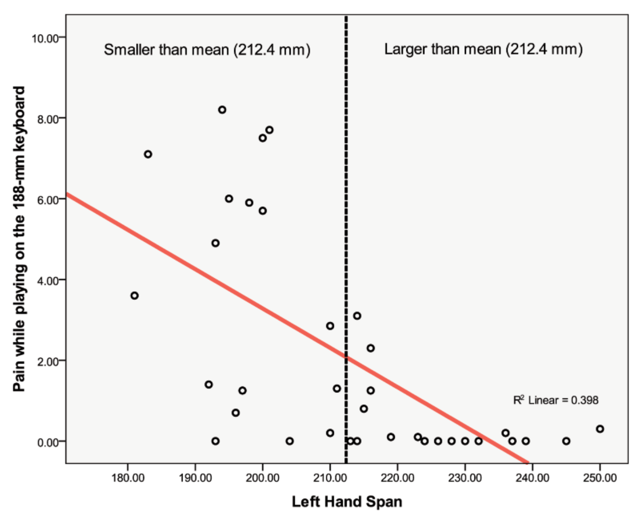
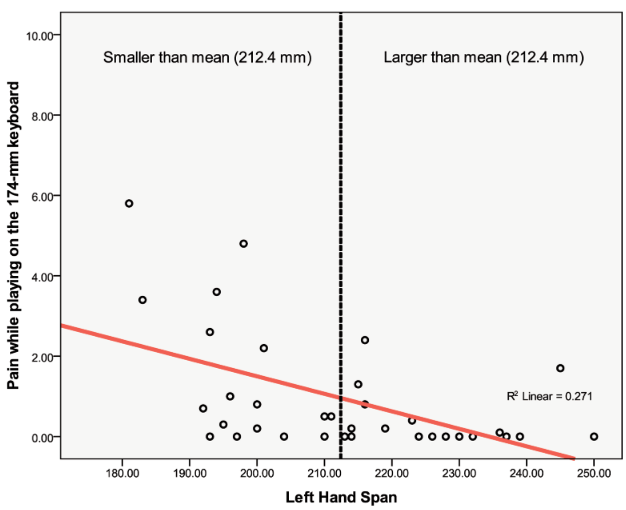


***Figure 6b:** Scatterplot and Regression Line of Left Hand Span (X) and Pain on the **174-mm** Keyboard (Y)*



As indicated in Table 5, subjects with smaller hands (< 212.4 mm) reported significantly more pain ($p < 0.05$) and tension ($p < 0.05$) than students with larger hands (> 212.4 mm).

Table 5: Mean Comparison of Pain and Tension Between Small and Large Hands

		Left Hand Span (mean = 212.4mm)	N	Mean (SD)	t-value	Sig. (2-tailed)
188-mm keyboard	Pain while playing	Larger (> 212.4mm)	18	0.45 (0.89)	-4.504	0.000
		Smaller (< 212.4mm)	17	3.78 (3.00)		
	Tension while playing	Larger (> 212.4mm)	18	1.79 (1.91)	-3.251	0.003
		Smaller (< 212.4mm)	17	4.63 (3.14)		
174-mm keyboard	Pain while playing	Larger (> 212.4mm)	18	0.39 (0.70)	-2.479	0.018
		Smaller (< 212.4mm)	17	1.55 (1.85)		
	Tension while playing	Larger (> 212.4mm)	18	1.36 (1.91)	-2.104	0.043
		Smaller (< 212.4mm)	17	3.08 (2.86)		
		Right Hand Span (mean = 209.7mm)				
188-mm keyboard	Pain while playing	Larger (> 209.7mm)	18	0.61 (1.05)	-3.849	0.001
		Smaller (< 209.7mm)	17	3.61 (3.13)		
	Tension while playing	Larger (> 209.7mm)	18	2.07 (2.14)	-2.472	0.019
		Smaller (< 209.7mm)	17	4.34 (3.23)		
174-mm keyboard	Pain while playing	Larger (> 209.7mm)	18	0.39 (0.70)	-2.479	0.018
		Smaller (< 209.7mm)	17	1.55 (1.85)		
	Tension while playing	Larger (> 209.7mm)	18	1.39 (1.89)	-2.025	n.s.
		Smaller (< 209.7mm)	17	3.05 (2.89)		

All questions were answered on VAS (0-10 cm)
Significance level (p < 0.05)

Further illustrating the influence of keyboard size, Table 6 shows that pain and tension were always lower with the 174-mm keyboard when compared to the 188-mm keyboard regardless of hand size. However, only the smaller handed group reported significantly different levels of pain ($p < 0.05$) across the two keyboard sizes.

Table 6: Mean Difference of Pain and Tension across Two Keyboards

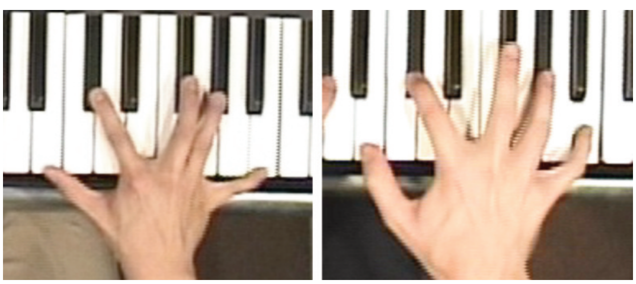
Left Hand Span (mean = 212.4 mm)			N	Mean (SD)	t	Sig. (2-tailed)
Larger (> 212.4mm)	Pain while playing	188-mm keyboard	18	0.45 (0.89)	0.296	n.s.
		174-mm keyboard	18	0.39 (0.70)		
	Tension while playing	188-mm keyboard	18	1.79 (1.91)	0.837	n.s.
		174-mm keyboard	18	1.36 (1.91)		
Smaller (< 212.4mm)	Pain while playing	188-mm keyboard	17	3.78 (3.00)	3.497	0.003
		174-mm keyboard	17	1.55 (1.85)		
	Tension while playing	188-mm keyboard	17	4.63 (3.14)	3.060	0.045
		174-mm keyboard	17	3.08 (2.86)		
Right Hand Span (mean = 209.7 mm)			N	Mean (SD)	t	Sig. (2-tailed)
Larger (> 209.7mm)	Pain while playing	188-mm keyboard	18	0.61 (1.05)	0.864	n.s.
		174-mm keyboard	18	0.39 (0.70)		
	Tension while playing	188-mm keyboard	18	2.07 (2.14)	1.151	n.s.
		174-mm keyboard	18	1.39 (1.89)		
Smaller (< 209.7mm)	Pain while playing	188-mm keyboard	17	3.61 (3.13)	3.175	0.006
		174-mm keyboard	17	1.55 (1.85)		
	Tension while playing	188-mm keyboard	17	4.34 (3.23)	2.708	n.s.
		174-mm keyboard	17	3.05 (2.89)		

All questions were answered on VAS (0-10 cm)
Significance level (p < 0.05)

Analysis Of Hand Posture

Figure 7 displays the images of the subjects with the smallest and largest right hand span among the study population playing the same chord (B-C#-G#-B) on the 188-mm keyboard. Visually, the difference in hand position and posture is evident. The fingers of the small hand seem uncomfortably stretched-out and are barely reaching the octave. In contrast, the fingers of the large hand appear to be naturally curved and easily pressing all four keys. As Table 2 reports, the hand span difference of these hands are about 7 cm (2 ¾ inch). The distance is equivalent to the width of three piano keys.

Figure 7: *Smallest Hand (span: 183 mm) and Largest Hand (span: 250 mm) on the 188-mm Keyboard*



The images shown in Figure 8 (a,b,c) are right hands with less than 200-mm hand spans. When the same chord was played on both keyboards, the angle between digits 2 and 4 is smaller on the 174-mm keyboard. Moreover, each hand looks more comfortable on the 174-mm keyboard compared to one on the 188-mm keyboard; (1) The thumb looks less stretched and more curved (Figure 8a); (2) fingers are centered more on the keys (Figure 8b); and (3) fingers 1 and 5 are reaching a wider range of keys (Figure 8c). These observations suggest that these subjects would be able to play with more dynamics and accuracy on the 174-mm keyboard.

Figure 8a: *Right Hand (span: 183 mm) Plays on the 188-mm (Left) and 174-mm Keyboard (Right)*

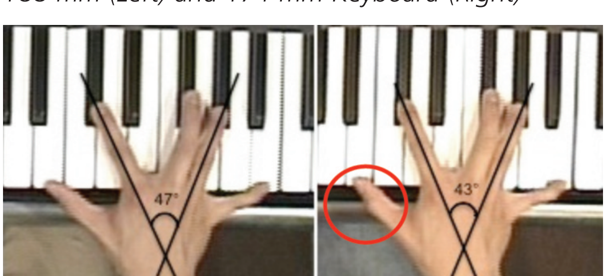


Figure 8b: *Right Hand (span: 190 mm) Plays on the 188-mm (Left) and 174-mm Keyboard (Right)*

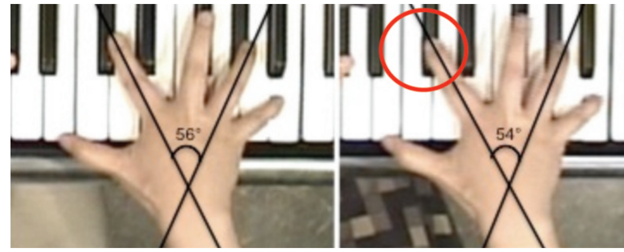
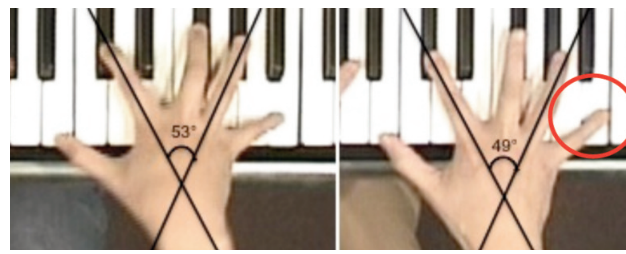
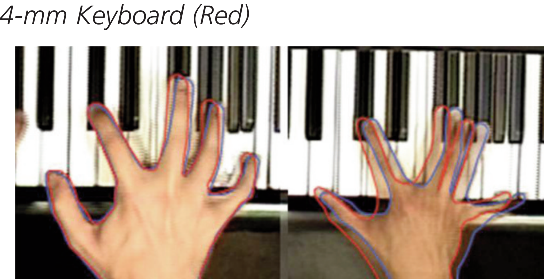


Figure 8c: *Right Hand (span: 197 mm) Plays on the 188-mm (Left) and 174-mm Keyboard (Right)*



Another way to observe the same hand on the two different keyboards is to outline and stack the images in order to see the differences. In Figure 9, the large hand postures are almost identical and both outlines are closely matched. Only the tips of the fingers are displaced slightly, and the span between fingers 1 and 5 is not changed. In contrast, postures of the small hand are significantly different as demonstrated by the two outlines. This suggests that the small-handed pianist experiences sensations associated with excessive stretch or range of motion when playing the 188-mm keyboard and less so when playing the 174-mm keyboard. One notable difference between the two images is that two keyboards appear to influence the entire small hand but only the placement of the fingertips for the large hand. In other words, the 174-mm keyboard would help the small-handed pianists more than the large-handed pianists by improving the posture of hands and reducing unnecessary extreme stretch.

Figure 9: *Stacked Images of the Largest Hand (Left) and Smallest Hand (Right)*
Outline for Right Hand on the 188-mm (Blue) and 174-mm Keyboard (Red)



Video A: *Large-handed pianist playing on the 188-mm keyboard*

Video B: *Small-handed pianist playing on the 188-mm keyboard*

Video C: *Small-handed pianist playing on the 174-mm keyboard*

Conclusion

To our knowledge, this is the first study of an ergonomically modified piano keyboard on playing-related pain among pianists. After performing on both modified and standard-size keyboards, overall playing-related pain and tension was less on the 174-mm keyboard than the 188-mm keyboard. Whereas pain increased from performing on the 188-mm keyboard, pain decreased from performing on the 174-mm keyboard.

Overall, the results from this study support the general and widely applied principles of ergonomics. Based on the results of this study, the fields of performing arts medicine and piano pedagogy can consider this approach as "evidenced-based" for dealing with playing-related pain—especially for pianists with small hands. However, this does not suggest that all musculoskeletal problems associated with piano playing are due to mismatches between hand span and keyboard size. Occupational injury causation is multidimensional, and this relationship represents only one important factor.

Due to the limitations associated with this study, additional research is warranted. Because this study included only 35 college music majors, larger sample sizes with more diverse and balanced subject populations are needed. Since the current study was limited to one two-week preparation period and only 45 minutes of practice time on a piano with the modified keyboard, additional studies are needed to explore acclimation periods and long-term effects on pain-related outcomes. This study also lacks data regarding key force and upper-extremity movement. The authors' most recent research includes force sensors and motion-capture cameras for biomechanical and kinematic evaluations.

Furthermore, future studies need to assess the influence of keyboard size on performance-related outcomes. Based on our experiences and observations, we believe an ergonomically modified keyboard may help some pianists extend the amount of practice time, perform wider chords as written without arpeggiating or leaving out notes, voice desired notes in certain chords, play relaxed and with reduced muscle tension or expand repertoire to include pieces usually performed by large-handed pianists.

Discussion

Pianists' playing-related problems can be traced back to around 1830, about a century after the piano was invented. So-called "pianist's cramp" was a major struggle for Robert Schumann[15] and was recognized in a medical journal in the late 19th century.[16] Despite this long-term awareness that playing the piano can cause playing-related pain and other medical problems, research related to pianists' health is extremely limited. This lack of research may be due to the belief that pain is a normal and expected part of playing piano or due to unhealthy conditions, lifestyles and habits. Moreover, piano teaching and learning are traditionally viewed as subjective activities that rely heavily on the senses and steeped in long-held traditions. In our view, these tendencies stifled growth and contribute to a lack of scientific research and objective data designed to explore risk factors and solutions for prevention. Peter Bragges confirmed this problem when he reported scientific credibility in only 12 of 482 publications dealing with the prevalence and risk factors for playing-related musculoskeletal disorders of pianists.[17] In other words, there are many individuals offering insights and solutions but only a handful of scientific studies providing verification. Therefore, and because so much is at stake, information should be viewed critically because of its potential to mislead pianists. For example, numerous publications suggest stretching before playing the piano as a method to reduce the risk for injury.[18,19,20,21] The research data, however, is insufficient to verify that stretching actually helps prevent injury. On the contrary, our previous research showed that stretching increases risk.[22] Other evidence suggests that static stretching should be excluded from warm ups for strength and power activities[23] and that stretching significantly decreases muscular strength.[24,25,26] Other examples of the potential to mislead pianists are books and methods that limit or exclude relevant and important factors. For instance, one book suggests that, other than problems associated with non-music related medical conditions or trauma, all piano injuries come from inefficient use of the body and poor habits of movement.[27] Unfortunately, it is possible that some pianists with small hands will buy into this false assumption and then spend years trying to "discover and correct those poor habits." We have witnessed young pianists investing in these false assumptions, feeling guilty and doubtful, and then realizing their pain is directly related to their hand size and the problem can be relieved with simple ergonomic modifications. For some of these pianists, the self-doubt and perceived inability to play certain pieces is more devastating than the pain itself. The piano community must consider the ramifications of young pianists, perhaps with small hands, who read and trust these statements.

The results of the current study suggest an effective approach to reduce piano-related pain for small-handed pianists. However, the idea of using modified keyboards is foreign to the piano world, in part, due to the "standardization" of key width in late 19th century. To influence the potential adoption of modified keyboards, advocates should consider attitudes and concerns of potential users. For example, a few small-handed subjects in this study (hand span less than 200 mm) reported they were either unsure about the modified keyboard or would prefer the 188-mm keyboard to the 174-mm keyboard. Those that said they would prefer the 188-mm keyboard reported:

- I am used to playing the standard piano (x 3).
- Accuracy is easier, to me [sic], because it is really just as comfortable as the modified keyboard, and I am more at ease with the standard.
- Less slips.

The students reporting being not sure stated:

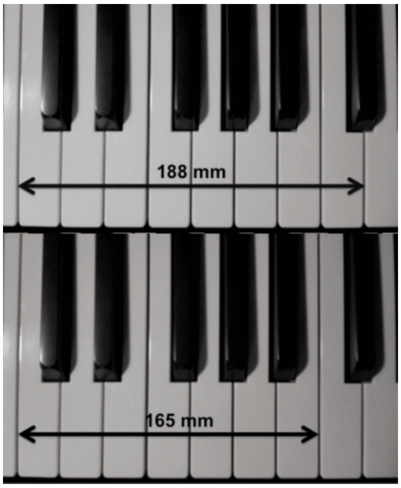
- The 174-mm keyboard is comfortable and less tension for forearm, but I already know standard piano and my muscle also know that piano [sic].
- Depends on the piece, if it requires big chord sound, I would like to use the modified keyboard because it makes my hands and shoulders more relaxed and less pain.

Although more research is needed, these quotes provide some insights into the attitudes and perceptions among small-handed pianists. Some seemed to choose the 188-mm keyboard simply due to its familiarity. This concern is understandable because pianists are accustomed to the "standardized" keyboard. Another concern is that they may be at a disadvantage when they travel to a new location or venue that does not offer or allow use of an ergonomically modified keyboard.

Several approaches are suggested to overcome these obstacles. First, to reduce students' fear of the unfamiliar, faculty and teachers need to inform students that it is not difficult to adjust technique, especially when their hands fit more naturally to the smaller keyboard. In fact, we encourage students to practice on both keyboards so switching becomes familiar. We encourage students to consider that switching is similar to what saxophonists do when switching from alto to tenor to baritone and back. The more one does this, the easier and more natural it becomes. Secondly, we recommend that piano manufactures offer optional key widths and that all National Association of Schools of Music (NASM) accredited institutions make ergonomically modified keyboards available for student pianists. These goals are challenging because of financial hurdles but worth the expense because of the large and growing numbers of female and Asian pianists attending these institutions. Moreover, considering the piano budgets of most major schools of music, this investment is reasonable in light of the size and scope of this problem.

Beyond these logistical considerations, the most challenging obstacle for embedding this idea into the piano world is the culture. Since the current keyboard size became labeled as the "standard," anything outside "normal" may be discriminated against. For this reason, the piano world should eliminate the term "standard" and rename keyboards based on key size. Under this rule, the "standard" keyboard should be called the "188-mm keyboard" and the modified keyboard we used in this study, the "174-mm keyboard." The measurement of octave span varies in literature and factories; however, the current study defines the octave span as the span of eight keys (188 mm), rather than seven keys (165 mm) as shown in Figure 10. Adopting a consistent labeling system would reduce confusion.

Figure 10: *Difference in measuring octave span*



Another major concern regarding the culture is that pianists genetically fortunate to have been born with large physical traits might label the use of an ergonomically modified keyboard as "cheating." This perspective has been observed and should be considered irresponsible and unsympathetic. Perhaps representing the pinnacle of such perspectives, some small-handed pianists are considered "less talented" because they struggle with a repertoire that requires playing larger chords or because they are no longer able to play due to pain. These issues reflect an unfortunate cultural phenomenon that needs to be changed on behalf of current and future pianists. Understanding beliefs and attitudes through survey research would be one approach to normalize opinions and acceptance levels towards the use of ergonomics. Hopefully all pianists would eventually agree that an ergonomic intervention to compensate for hand size is feasible and essential, just like adjusting the height of a piano bench to compensate for leg length and body height.

Being aware of the existing problems and available resources is an essential component to protect the health of students and professionals. To encourage awareness of music-related health risks and wellness through education, Health Promotion in Schools of Music (HPSM) was established by the University of North Texas (Texas Center for Music and Medicine) and Performing Arts Medicine Association (PAMA).[28,29] In response to HPSM recommendations, some NASM accredited institutions are now offering "Occupational Health" or wellness courses.[30,31,32] Some large organizations, such as MTNA,[33] the Frances Clark Center for Keyboard Pedagogy,[34] and the National Association for Music Education,[35] support this project and have encouraged additional efforts to educate student musicians about occupational health and wellness.

Looking forward, we see untold opportunities and challenges as we increase our understanding of the occupational health risks involved with learning and performing the piano. While our research informs us that modest ergonomic changes can reduce pain, the extent to which this option becomes available and applied is considerably less clear. Due to its rich history and resilient traditions, addressing the health risks associated with piano is challenging. However, if we continue to modify how we approach this issue and the social contexts in which these problems become socially patterned, widespread lasting change is inevitable.

NOTES

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Born in Osaka, Japan, ***Eri Yoshimura*** *earned a music education degree from Shinshu University before moving to Denton, Texas. There, she received a doctor of musical arts degree in August 2009 following a master's in piano performance degree from the University of North Texas under Pamela Mia Paul with a related field in music and medicine under Kris Chesky.*

Yoshimura's scholarly research has focused on understanding and preventing piano-related medical problems. Her research papers were published in the Medical Problems of Performing Artists *journal in 2006 and 2008. She is also interested in the application of an ergonomically modified keyboard (a narrower-sized keyboard) for reducing piano-related pain among small-handed pianists and has been using the modified keyboard at the University of North Texas for the last four years. She has presented her research in conferences at Aspen (PAMA), Chicago (NCKP), Serbia (EPTA) and England (RNCM). She won the research scholarship in 2008 and was featured on the university homepage and on a local news broadcast.*

Yoshimura has performed solo and four-hands recitals in the United States (including Hawaii), Japan, Mexico and Hungary (Franz Liszt International Festival) and participated in music festivals in Italy and Vienna. She and Hungarian pianist, Emöke Ujj, released their first album together, "Contemporary Piano Music for Four Hands" *(available at http://fourhandspiano.com/), which contains the works by four living composers. All compositions in this album were specifically composed for the duo.*

Kris Chesky *holds degrees from the Berklee College of Music and the University of North Texas. After completing his undergraduate degree in trumpet/jazz studies, he worked as a bandleader and sideman. During graduate studies at UNT, Chesky studied music therapy with Texas Women's University Professor Donald Michel while working for a psychiatric in-patient hospital in Fort Worth. After completing a doctorate degree, he conducted research on the pain-relieving effects of music vibration at the UNT Health Sciences Center, University of Texas-San Antonio and at Cook Children's Hospital of Fort Worth.*

Chesky is currently associate professor within the UNT College of Music and director of the Texas Center of Music & Medicine. He oversees and teaches courses in music medicine including an undergraduate course titled "Occupational Health: Lessons for Music." Chesky is executive director of the Health Promotion in Schools of Music project (www.unt.edu/hpsm) and holds leadership positions in the Performing Arts Medicine Association (www.artsmed.org) and the National Hearing Conservation Association (www.hearingconservation.org).

Chesky has received research grants from the National Endowment for the Arts, the Grammy Foundation, NAMM, IFMR, the Scott Foundation, and others to study health issues related to learning and performing music. He has published scientific research articles in the areas of epidemiology, biomechanics, audiology and mental health. Chesky has participated in many conferences over the past 15 years including some in Canada, England, France, Germany, The Netherlands, Spain, South Africa, Scotland and throughout the United States.