An introduction to the technical and musical benefits for pianists using reduced-size keyboards

For around 100 years there has been an almost universal ‘one size fits all’ approach to the piano keyboard, despite the wide variation in hand sizes within the human population. Much of the literature relating hand size to piano playing is in the performing arts medicine field, identifying small hand size as one of the possible causes of pain and injury among pianists. Adopters of reduced-size keyboards, available since the mid-1990s, report relief from pain and tension, and other benefits, such as improvements in specific technical and musical skills, faster learning times, and greater comfort and security.

FOR MANY years I (Rhonda) have been aware that the great pianist of the early 20th century, Josef Hofmann, had a smaller piano keyboard made specially for him by the Steinway company. I always assumed that the cost of having Steinway (or any other manufacturer) make a similar keyboard for me would be prohibitive. At the end of 2007 I was searching the internet for information on piano playing technique for small-handed pianists. I came across an article by Christopher Donison, a pianist, composer, conductor and lecturer in British Columbia. Donison, having particularly small hands for a male, had had a custom-made smaller keyboard made for his Steinway grand piano. His published papers (1998, 2000) on this subject elaborate on the significant technical and musical benefits for his own piano playing. In the early 1990s Donison met up with Pennsylvanian textile manufacturer and engineer, David Steinbuhler. Together they created a second official keyboard size (the DS standard™), with the long term aim of it becoming universally available.

During the two and a half years since that internet discovery I have studied the literature relating to hand size and the piano keyboard, established contact with David Steinbuhler and ordered my own 7/8 keyboard. This was custom-made to fit my Bernstein grand piano and was installed in early April 2009.

Hand size and piano keyboard size

Between 1998 and 2005 Steinbuhler & Company invited adult pianists to experiment with a complete range of piano keyboard sizes at their centre in Titusville, Pennsylvania. Participants were able to spend hours or days experimenting and swapping between the different size keyboards. It became clear there was a strong desire for at least two smaller keyboard sizes in addition to the conventional keyboard. To determine the most practical size keyboard for the smaller-handed pianists, a detailed study was conducted using five keyboards measuring between 38 and 42 inches in overall width. About 15 pianists experimented with these keyboards. Although there was a general desire to play the smallest keyboards, it was found that below 40 inches the space between black keys became too cramped for all but those with the smallest hands with thin fingers. Hence, 41 inches was selected as the best available choice for the smallest hand-size. Three standards were subsequently defined as follows:

- Conventional keyboard – 6.5 inch octave, 48.29 inch total width
- 15/16 Universal keyboard – 6.0 inch octave, 44.57 inch total width
- 7/8 DS Standard™ keyboard – 5.54 inch octave, 41.14 inches total width

In addition, at the US Music Teachers National Association (MTNA) 2004 National Conference, attendees were invited to play these keyboard sizes and have their hand spans measured. Of the 160 who agreed to participate, 90 were adult females, 66 were adult males and four were students still growing. The distribution of their ‘active 1-5 hand spans’ is shown in Figure 1, a chart created by David Steinbuhler. A mix of left and right hands were measured. While not a random sample, the gender difference is obvious from the graph.

What is your Hand Span?

Using the Hand Gauge on the back of this card, a pianist can measure the span of his or her hand to see how it compares with the hands and zones represented in this chart.

- Male Hand
- Female Hand
- Student Still Growing

Steinbuhler & Company

The hand span data in this chart was collected at the 2004 MTNA National Convention.

Figure 1: Pianists' hand spans measured at the MTNA Convention in 2004 (www.steinbuhler.com)

1 Octave measurements given represent the total width of 7 white keys.
2 Distance in inches from thumb to fifth finger stretched to the maximum
Comparing earlier anthropometrical data on pianists’ hands (Wagner, 1988) with the MTNA data, the results are broadly consistent, although there were no females with hand spans of 9 inches and above measured at the MTNA Convention. Assuming hand span data for a sufficiently large sample would approximate a normal distribution, various summary measures can be derived. Table 1 summarises the differences between males and females for the two data sets.

### Table 1: Steinbuhler and Wagner hand span data (inches)

<table>
<thead>
<tr>
<th></th>
<th>Steinbuhler 2004</th>
<th>Wagner 1988</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td>Number of respondents</td>
<td>66</td>
<td>90</td>
</tr>
<tr>
<td>Minimum</td>
<td>7.7</td>
<td>7.0</td>
</tr>
<tr>
<td>Maximum</td>
<td>10.2</td>
<td>8.9</td>
</tr>
<tr>
<td>Arithmetic mean</td>
<td>8.9</td>
<td>7.9</td>
</tr>
<tr>
<td>Median</td>
<td>8.9</td>
<td>7.9</td>
</tr>
<tr>
<td>First Quartile</td>
<td>8.5</td>
<td>7.5</td>
</tr>
<tr>
<td>Third Quartile</td>
<td>9.3</td>
<td>8.2</td>
</tr>
</tbody>
</table>

It is interesting to consider whether the size distribution of pianists’ hands reflects the human population as a whole, and the influence of ethnic origin. From measurements of many different features of the human hand in the US (Garrett, 1971), depending on the characteristic measured, differences between males and females generally range between 10% and 20%. However, for the active 1-5 span, he does not give gender differences; he gives an overall mean of 8.5 inches for males and females combined. Wagner (1988, p.117) notes that based on previous studies, musicians tend to have greater finger spans than non-musicians.

A significant proportion of subjects (95% of males and 86.5% of females) measured by Wagner (1988) were of Caucasian origin. The ethnic background of MTNA pianists (Figure 1) is unknown but is likely to be mixed.

In the absence of other data and recognising that the data do not come from scientifically-based random samples, from Table 1 one could postulate that:

1. Comparing the first quartile of males with the first quartile of females, approximately 75% of adult females have hand spans smaller than the 75% of adult males with the largest spans, and

2. Comparing the arithmetic means and medians, the average hand span of an adult male is approximately one inch greater than that of an adult female (representing almost the width of one key on the conventional keyboard).

Figure 2 illustrates these findings.

It is useful to relate hand span to the capacity to stretch a specified interval on the conventional keyboard. [Although ability to reach certain intervals is only one of the many suggested benefits of reduced-size keyboards, it is a fundamental constraint on the ability to perform certain repertoire.] To calibrate 1-5 active hand span against ability to play different intervals, in March 2009 we measured the hand spans of around 25 adult pianists and documented the largest white key interval they were able to play – either comfortably (ability to slide thumb and fifth finger in towards the black keys) or just reaching ('on the edge' of the white keys). The results are shown (without gender differences) in Table 2. Note that the total widths of these three intervals, as measured across a conventional keyboard, is approximately the same as the threshold hand span, e.g. width of a 9-note white key interval (covering 10 notes in total) is 8.4 inches.

### Table 2: Hand span and white key interval calibration

<table>
<thead>
<tr>
<th>Approximate threshold - active hand span (1-5)</th>
<th>Capacity to play white key intervals</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.5 inches Octave: comfortable; 9th: 'on edge'</td>
<td></td>
</tr>
<tr>
<td>8.4 inches</td>
<td>9th: comfortable; 10th: 'on edge'</td>
</tr>
<tr>
<td>9.3/9.4 inches 10th: comfortable; 11th: 'on edge'</td>
<td></td>
</tr>
</tbody>
</table>

Relating these findings to the statistical summary measures shown in Table 1 and in Figure 2, it is postulated that a significant minority of females cannot play an octave comfortably on the conventional keyboard, and a significant majority cannot play a ninth comfortably, nor a tenth even 'on the edge'. On the other hand, it seems that a significant majority of males can play an octave and a ninth comfortably and a tenth 'on the edge' using the conventional keyboard. (See Figure 3.)

Figure 3: Intervals that can be played comfortably according to hand span

It is postulated that by transferring to a 7/8 keyboard, one extra white note is added to the maximum interval that can be played by any individual, i.e. in effect, their hand span becomes one inch larger, compared with playing the conventional keyboard. For example, someone with a 7-inch span becomes (on the 7/8), equivalent to a person with an 8-inch span on the conventional keyboard. The average 8-inch female hand span on the 7/8 is approximately equivalent to the average 9-inch male hand span on the conventional keyboard. The female hand distribution graph (Figure 2) effectively moves to the right to the position of the male hand span distribution. This means that the female hand is approximately in the same proportion to the 7/8 keyboard as the male hand is to the conventional keyboard.

Piano keyboards have not always been the size they are today. In the 18th century they were not only smaller than today (similar in size to current day harpsichords) but at that
time, repertoire rarely contained intervals larger than an octave. At the beginning of the 19th century the piano keyboard was gradually extended in range and size (Deahl & Wristen, 2003) and the use of cast iron frames led to an increase in string tension, resulting in heavier and deeper action. During the 19th century, a Czech company designed a smaller keyboard ‘for ladies’. As the piano evolved, the need for standardisation increased as pianists (professional or amateur) started to travel outside their own communities, hence the ‘one size fits all’ approach that has prevailed over the last century.

**Hand size as a risk factor in piano-related pain and injury:**

**Epidemiological studies**

Much of the literature linking hand size with piano playing is in the field of performing arts medicine, with the focus on hand size as a possible risk factor in piano-related pain and injury based on epidemiological studies.

Many such studies published during the 1980s and 1990s covered a mix of instrumentalists rather than just pianists. These included clinical studies (Fry 1987, Manchester & Fleder, 1991; Cayea & Manchester, 1988), a survey of teachers (Quarrier, 1995) and a detailed case-controlled study of risk factors (Zaza & Farewell, 1997). Likely causes of pain or injury were identified as being technique, time and intensity of practice, posture and genetically based factors. Females were found to be disproportionately affected and keyboard players among those most at risk.

In a survey of piano teachers’ perceptions of risk factors for injury in elite pianists at the University of Melbourne and the Victorian College of the Arts (2006), Bragge et al. (2006) found that the top five risk factors identified were technique, muscular tension, teacher, seat height and repertoire. Hand size was nominated in sixth position. But Deahl & Wristen (2003), in developing strategies for small-handed pianists, noted that small-handed pianists are at higher risk of developing injury due to greater degrees of lateral wrist motion, flexion, extension and deviation that are required than for larger-handed players. Large chords, octaves and arpeggios repeatedly force small hands out of an ‘anatomic neutral’ position. This is consistent with the conclusions of Sakai’s (1992, 2002) clinical studies where he identified the playing of octaves and chords as likely causes of pain and injury.

**Pilot Studies of the Benefits of Reduced-Size Keyboards**

Use of reduced-size keyboards in research is a very new field of activity. Apart from two recent university-based pilot studies (Wristen et al., 2006; Davis & Evans, 2007), the remaining evidence of benefits to pianists is derived from personal experiences of those who play them regularly. While the bulk of the literature described above links hand size to pain and injury among pianists, the potential benefits of reduced-size keyboards are much wider – extending into the execution of technical skills with required speed and accuracy, ease of learning and musicality.

Wristen et al. (2006) conducted a study of small-handed pianists (defined as having active 1-5 spans of 8 inches or less) that involved the use of electromyography to provide empirical data on physical ease. Measurements were taken of muscle loading, hand span, wrist flexion and extension, and radial and ulnar deviation during performance of specified musical excerpts. The trials involved playing a particular keyboard, structured practice sessions, and transitioning to the other keyboard. The trials were also recorded and assessed by a panel of experts and results were compared with self-assessments. Both the 7/8 and conventional keyboards were used for comparative purposes.

The results of this study indicated that the subjects’ self-reported best performance matched the expert assessment. The 7/8 keyboard was preferred by all pianists based on their overall feeling of comfort, and this was substantiated by the expert assessment based on missed keys, pauses and the empirical data including range of hand span required, measured joint angles and force loadings. The authors concluded that use of the 7/8 keyboard would result in easier and more enjoyable practice for these pianists.

Davis & Evans (2007) studied the adaptability of five small-handed pianists to the 7/8 keyboard. After learning two Chopin Preludes, set exercises and a piece of their choice, their performances were recorded on the conventional keyboard and immediately after (with no practice) on the 7/8. Following a week of structured practice on the 7/8, their performances were again recorded on the 7/8 keyboard. Blind assessments of accuracy and continuity were made by a panel of three teachers and an attitudinal survey of the pianists was also conducted.

Results indicated an initial drop in performance quality when moving from the conventional keyboard straight to the 7/8, but a subsequent improvement on both initial performances at the end of the week. Four of the five pianists agreed that initial adaptation was as hard as they expected, but also agreed that after a little practice, adaptability was easier than expected.

**Individual Users’ Accounts of the Benefits of Reduced-Size Keyboards**

Two North American pianist-academics, Carol Leone (2003) and Christopher Donison (1998, 2000), have commented on the significant benefits of reduced-size keyboards for their own playing. Both Leone and another academic, Lora Deahl (personal communication), have also commented on the

A summary of comments from Leone and Donison is as follows:

**Adjustment and swapping between keyboards**

- Surprisingly, adjusting to the new keyboard size generally takes no more than one hour. The most challenging interval to get used to is the new octave. The most gifted pianists and children tend to adjust almost immediately.
- Going back and forth between the two keyboards, assuming both are played regularly, also presents little problem. It is described as like swapping between two different family cars. Organists and harpsichordists deal with this issue regularly, as do violinists who play the viola regularly.
- Some students have elected to use a specific keyboard for different repertoire, for example Bach and Beethoven on the conventional and Ravel on the 7/8.
- Learning a piece on the 7/8 prior to playing on the conventional can help the learning process and result in less tension after making the transition.

**Technical differences**

- Playing on the smaller keyboard involves smaller movements and less use of throwing, pivoting, rotating and general “flying about”.
- Fingers are closer to the keys and wrists do not have to strain in a high position to reach a greater span.
- Hand position changes are reduced and marked fingering is more likely to make sense.
- Rolled cords and pedalling to mask notes not held manually are reduced or eliminated.
- Leaps and wide spread arpeggio-type figures feel much more secure.
- Chords and octave passages lie much more “under the hand”, which is more compact and less stretched.
- Learning, memorisation and sight-reading are improved or accelerated, particularly for technically difficult sections.

**Musical differences**

- Improved legato and musical line with less reliance on the pedal.
- Ability to perform legato octaves.
- Increased power due to the hand being more compact.
- Improved voicing of chords and balance.
- Ability to spend more time on musical aspects rather than just focusing on hitting the right notes.

Lora Deahl gathered preferences from 100 students, including children, regarding preferences for the conventional versus 7/8 keyboard. There were statistically significant differences between females and males in their preferences when performing four specific tasks: C major 4-note chord (root), C major 4-note chord (first inversion), diminished seventh arpeggios (root) and dominant seventh arpeggios (root). In each case, females preferred the 7/8 and males preferred the standard. Children also preferred the 7/8 keyboard.

**Personal reaction to the 7/8 Keyboard**

At the time of writing, I (Rhonda) had had a few weeks of playing the 7/8 keyboard since its installation. My own hand size is as follows:
- active 1-5 span – 7.0 inches
- active 2-5 span – 4.7 inches.

The implications of this hand size are that on a conventional keyboard I can only play octaves ‘on the edge’ of the white keys, which precludes the playing of any fast octave passages. The particularly poor flexibility between my non-thumb digits also means that many octave-based 4-note chords are not playable. Essentially, I can only play second inversion chords with the right hand and root position chords with the left hand. I cannot stretch a 6th using digits 2 and 5. I have not suffered any injury - perhaps partly due to a previously very restricted repertoire.

My first attempt at playing the new keyboard resulted in over-shooting octaves but this tendency was much reduced after 30 minutes or so. Within an hour I felt reasonably comfortable and was able to play existing repertoire with no great difficulty. The narrower black keys were not an issue. With some repertoire, I am now able to play previously omitted notes or use more appropriate fingering. Becoming secure with such changes requires just a few practice sessions, as is normally the case when making these sorts of changes.

Overall, the improvements I expected to feel were immediately apparent, in particular:
- ability to play octaves with comfort (probably the most dramatic improvement)
- ability to play nearly all chords as written, rather than constantly deciding which notes to omit
- ability to hold notes down as intended
- much greater ease with broken octaves, broken chords and arpeggios
- the much greater feeling of power
- reduction in uncomfortable stretching with the hands being in a more relaxed position for a much greater proportion of playing time
- improved legato lines within chords (e.g. Brahms Intermezzo Op. 117, No.1) linked to the ability to use appropriate fingering rather than successive thumbs or 5th fingers
- easier sight-reading of pieces containing large chords/octaves.

Other types of playing that also felt much easier, but were less expected, include:
- for chords that are meant to be rolled (e.g covering a 10th or more), the reduced distance to roll has a big impact on the feeling of security, particularly when the other hand is performing something fast or complex (for example Chopin Prelude No. 10 in C# minor)

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sweeping passages (such as in Chopin Preludes Nos. 3, 11, 18 and 23) feel much more secure as a result of the hand being more compact.

- the wide-ranging implications of being able to stretch a 6th using the 2nd and 5th fingers, whether within chords or in single legato lines.

- less unevenness of rhythm, (such as in Mozart or Beethoven pieces), due to the hand being more compact and not having to suddenly jolt into a stretched position when moving to or from an octave.

The experience of playing the 7/8 keyboard provides an appreciation of the real impact of hand size. My 7-inch hand on the 7/8 is equivalent to an 8-inch hand (average for females and well below average for males) on the conventional keyboard. As an example, when playing the Chopin Etude Op.10 no.5 (a piece I have played since the age of 17), the difference between the two keyboards is dramatic. The improvements include extra speed (from 80 crotchet beats per minute to over 90), significantly improved legato and shaping in the right hand, disappearance of any right forearm pain due to excessive tension from stretching (bars 57-64), and a much better feeling of comfort and control. Crucial to these improvements is the ability to use appropriate fingerings instead of successive thumbs and fifth fingers in many parts of the piece. I believe that a larger hand would lead to even greater facility and ease. An 8-inch span is inadequate when attempting to play the final left-hand triplets (which span 10ths) accurately and at speed.

**Conclusions**

Data on the distribution of hand size within the general population are not readily available, but it is self-evident that there is much variation between individuals, and between males and females, and between adults and children.

From a review of the epidemiological literature, there is strong evidence for a link between hand size and pain and injury rates among pianists. This is supported by evidence from the sciences of ergonomics and biomechanics, and from recorded personal experiences.

Technical and musical benefits of reduced-size keyboards for smaller-handed pianists appear to be far-reaching. Improvements which appear to be among the most dramatic (ease with fast passages of octaves and large chords) have also been documented as a major factor leading to pain and injury among small-handed pianists.

Based on evidence, small hand size appears to be a significant impediment to many pianists. It seems the conventional keyboard especially disadvantages females, often preventing them from reaching their full potential. It is likely that a significant minority of females, particularly those of Asian ethnicity, cannot play octaves with comfort, and a majority of females are unable to play 10ths. From the results of research and a survey conducted by the authors and others, one could postulate that at least 50% of adult female pianists (those with hand spans of 8 inches or less) could perform at a higher level on a reduced-size keyboard.

According to statistical analysis we have undertaken, it is possible that the proportion of pianists who would benefit from reduced-size keyboards may be even greater. This would apply particularly to Romantic and 20th century repertoire where being able to play a 10th is frequently expected. This requires a hand span of at least 8.4 inches which rules out a significant minority of males in addition to the majority of females. Indeed, the Steinbuhler Company (personal communication) indicates that approximately 20% of customers for reduced-size keyboards are male.

The availability of reduced-size keyboards opens up research opportunities that have not been practicable in the past. This provides a way of testing how the performance of a particular player might change according to keyboard size. This would enable enables researchers to isolate hand size as a factor influencing performance quality.

Further detailed research could explore technical and musical skills and how these vary on reduced-size compared with conventional keyboards. A rigorous approach could involve standard repertoire and practice routine and blind assessments of recordings by expert panels. It may also be possible to relate specific skill improvement to hand size within the 'small-hands' group, for example, in relation to sight-reading. There are also research opportunities involving children and teenagers.

Finally, one could invent and test the performance of exercises for larger-handed pianists that replicate the experience for small-handed pianists, such as broken 10ths compared with broken octaves.

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**The Steinbuhler 7/8 keyboard prior to installation**

**About the Authors**

- Rhonda Boyle (née Jones) studied the piano as a child in Geelong, winning prizes at eisteddfods and completing AMEB examinations with honours. She studied science at Melbourne University, majoring in geophysics, and later completed masters' degrees in environmental science and urban planning. Her career has mostly been with the Victorian State Government where she has worked in the fields of metropolitan planning, environmental science and policy development. Her publications include a research paper commissioned by the OECD. Rhonda returned to piano studies ten years ago as a private student of Robert Chamberlain, a well-known concert pianist and university level teacher. She recently purchased a 7/8 keyboard for her grand piano.

- Robin Boyle lectures in statistics in the Faculty of Business and Law, Deakin University. He studied economics and mathematics at the University of Tasmania and later completed a master's degree in administration at Monash.
University. His principal academic pursuit has been the writing of statistical software. His research interests are restricted to practical applications of statistics in investigating real world problems, such as the dilemma facing small-handed pianists. He has always had a love for classical music, the piano in particular. He completed elementary piano studies, and has been learning singing in the classical tradition for the last nine years.

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