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Translating Taubman: The biomechanics of "curling the fingers" in piano technique

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Abstract

Piano technique is considered significant to performance quality and the prevention of playing-related injuries. Both teachers and researchers stand to benefit from exchanging knowledge on this topic. However, differences in biomechanical and technical terminology can pose challenges for communicating and scientifically evaluating ideas about piano technique. Therefore, it would be beneficial to translate terminology across disciplines to allow successful knowledge exchanges. This study addresses linguistic difficulties related to the Taubman Approach to piano technique, which has gained prominence as a pedagogical approach. A two-stage qualitative method was used to extract key ideas from Taubman Approach sources, and to translate them into scientific language. Findings are given for two main categories related to curling the fingers: 1) What is curling? and 2) Does curling lead to physical/musical problems? The biomechanical translation of Taubman Approach sources suggests that curling involves flexing the distal interphalangeal joints by activating extrinsic flexor muscles. Further, curling while playing the piano may increase co-contraction and stiffness across the wrist/finger joints, inhibiting movement in multiple planes and potentially leading to technical limitations and/or injury. This study provides an example of how pedagogical language can be translated into scientific language. These findings can clarify concepts, help bridge communication gaps, and provide a basis for further research on piano technique and injury development. Findings can also help teachers better understand Taubman's concept of curling, and why she believed it should be avoided. Finally, findings provide teachers with anatomical and biomechanical concepts that can help their students better understand piano technique.

Keywords

biomechanics, piano technique, piano pedagogy, musicians' injuries, Taubman Approach

Introduction

Terminology note: Technique-specific terms from the Taubman Approach are introduced in italics at first mention and used thereafter in plain text without special formatting.

Piano technique is considered significant to performance quality and the prevention of playing-related injuries (Catellani et al., 2024; Turner et al., 2022). While piano teachers play an important role in shaping students' technique, many disagree about what constitutes correct or healthy technique (Wheatley-Brown et al., 2014). For example, finger mechanics are considered fundamental to appropriate technique (Takamizawa & Kenway, 2023), but popular methods provide conflicting advice about what finger position and movements beginners should adopt when playing (Wheatley-Brown et al., 2014). While several scientific studies have examined pianists' finger mechanics (see Jurinić et al., 2025 for a review), pedagogy is often based on experience and historical tradition, rather than science (Takamizawa & Kenway, 2023). Further, many scientific studies on this topic have methodological limitations that restrict their practical value for performers and teachers (MacRitchie, 2015). Some teachers have designed approaches to help students improve performance and health outcomes by combining scientific knowledge and teaching experience (Zhou, 2021). Approaches that have achieved anecdotal success in doing so may have useful knowledge to contribute to both pedagogical and scientific discussions on piano technique (Sabo et al., 2023).

The Taubman Approach

The Taubman Approach (TA) was developed by Dorothy Taubman (1917–2013), who was widely recognized for her work in rehabilitating injured pianists (Schweitzer, 2013). Over many decades of teaching and consulting available scientific sources, Taubman designed her approach based on basic principles about the body and instrument (Urvater, 1986). She felt that differences in performance ability and injury development were influenced more by pianists' playing technique than by talent or other factors (Urvater, 1995, Vol. 1). She felt several common sources of tension were likely to lead to technical limitation and injury (Milanovic, 2012). Her pedagogical approach consisted of both "quick fixes" to technical problems and comprehensive retraining (Dyer, 1995). In both cases, she found that re-education could simultaneously improve students' technical abilities and treat symptoms of injury (Wolff, 1986). Since Taubman's death, her former students have disseminated her approach internationally, most notably through the Golandsky Institute (Golandsky Institute, n.d.).

Research problem

The TA's anecdotal success suggests it could contribute to broader knowledge on the biomechanics of piano technique and injury development. However, despite the TA's increased popularity in recent decades, many of Taubman's ideas remain to be scientifically examined. One possible reason for this is her use of language (Sabo et al., 2023), which was developed to provide practical insights for pianists and teachers (Milanovic, 2012). Generally, piano teachers' ideas can be delivered in many forms (demonstrations, metaphorical descriptions, etc.) that are not easily represented in scientific discourse (Goebl, 2017). While the TA includes some scientific language, many terms were taken from sources that Taubman consulted decades ago and are either outdated (e.g., some terms used in Ortmann, 1929) or used differently from their current scientific meaning (Wheatley-Brown et al., 2014). This combination of factors has resulted in the TA containing language that has varying consistency with modern science. Therefore, it is necessary to understand her language in scientific terms before knowledge exchange can occur across disciplines (Sabo et al., 2023).

This study examined some of Taubman's ideas related to *curling the fingers*, which is one of the sources of tension outlined in the TA (Milanovic, 2012) and could provide useful insights into broader discussions about finger mechanics in piano technique. This paper details a subset of findings from a larger study on curling. First, it outlines a broad biomechanical definition of the term "curling" as used in the TA. Then, it describes ways that the TA suggests curling may lead to injuries and technical limitations.

Method

This study used the two-stage methodological framework developed by Sabo et al., (2023) for extracting pedagogical ideas and translating them into scientific language. The research team included a piano teacher with prior training in the TA (first author) and experts in piano pedagogy (second author), the TA (third author), and biomechanics (fourth author).

Stage 1 used Qualitative Content Analysis (QCA) (Schreier, 2012) to create a descriptive summary of pedagogical ideas ("Pedagogical Summary," Sabo et al., 2023). QCA was performed on excerpts from four TA sources:

1. Five DVDs detailing the TA (Urvater, 1995)
2. Conference presentation written by Taubman (1984)
3. Method book to guide students through basic elements of the TA (Moran, 2008)
4. Doctoral thesis detailing the author's experience studying and teaching the TA (Milanovic, 2012, chapters 4-5)

The first two sources were considered primary, since Taubman was directly involved in their creation. The third and fourth sources were used to provide greater detail and reflect more recent TA developments. The QCA method (Schreier, 2012) used in this framework contains four steps:

1. Data preparation: sources were prepared for analysis, and videos were transcribed. Transcriptions were reduced to only include statements, text, and images related to finger position/movement.
2. Coding Frame Development: TA sources were summarized using a coding frame, developed based on key ideas from pedagogical sources.
3. Pilot Phase: the coding frame was tested on a "representative sample" of source materials to make necessary changes before final coding.
4. Main Analysis: Final coding was performed by the first author and later repeated on a subset of excerpts by the third author. Both coders discussed areas of disagreement until they were resolved.

After QCA, a "Taubman Approach Summary" was written to encapsulate the main ideas in each subcategory. The third author reviewed each summary as an expert consultant to ensure its validity and suggest necessary changes.

Stage 2 involved iteratively consulting pedagogical and scientific sources to produce a valid translation. Researchers identified key terms and concepts from Stage 1 findings and used scientific sources to produce translations that explain the biomechanical underpinnings of phenomena described in each subcategory. Scientific sources mainly included those written for health researchers and practitioners. Language was understood as functional, and used to achieve certain aims in a particular context (Tylén et al., 2010). The researchers used their embodied knowledge of piano playing and the TA to guide the analysis. As with Stage 1, expert consultation helped increase the validity of the translations. The fourth author was consulted during Stage 2 as a biomechanics expert. The third author reviewed translations as a TA expert.

Results

Category 1: What is curling?

The first main category focused on defining curling the fingers as outlined in the Taubman Approach sources. Table 1 provides pedagogical and biomechanical definitions for each subcategory.

Table 1
What is curling?

Subcategory	Biomechanical analysis	TA sources
1. Curling is pulling fingers in from nail joint	Curling fingers 2-5 involves actively flexing the distal interphalangeal joints (DIP) joints of the fingers. Doing so will also flex the proximal interphalangeal joints (PIP) joints. It is unclear from this category alone how much flexion is considered curling, as well as if passive flexion is also considered curling.	Taubman, 1984; Urvater, 1995, Vol. 1; Moran, 2008
2. Fixating causes dual muscular pulls	Curling is a form of fixation, which involves increasing the stability of the finger joints by co-contracting muscles. This also increases the stiffness of those joints. It can also be a form of molding, which may refer to fixating in a position outside of resting position.	Urvater, 1995, Vol. 1
3. Curling uses the long flexor muscle that pulls tightly under the wrist/fingers	Actively flexing the DIP/PIP joints requires contracting extrinsic finger muscles (flexor digitorum profundus or FDP/ flexor digitorum superficialis or FDS), which are on the volar (palm) side of the forearm. Active DIP flexion requires contracting the FDP muscle. Because DIP flexion also causes PIP flexion, the FDS muscle may also contract. The FDP/FDS are multiarticular muscles, so activating them for DIP/PIP flexion will likely produce co-contraction of extensor muscles to prevent the wrist/ metacarpophalangeal joints (MCP) joints from also flexing.	Taubman, 1984; Urvater, 1995, Vol. 1, 3; Milanovic, 2012
4. Curling restricts up and down hand/finger motion	The increased stiffness caused by the co-contraction involved in DIP/PIP flexion will generate forces that resist any attempt to flex or extend the wrist/finger joints. This will increase the muscle force needed to produce rotation about those joints. Increasing muscle forces will also decrease the potential velocity and range of motion of these movements.	Taubman, 1984; Urvater, 1995, Vol. 1; Milanovic, 2012

5. Curling prevents opening the hand/6. Curling and stretching together creates dual muscular pulls	The muscles that abduct the fingers also act to extend them. Therefore, trying to simultaneously flex/abduct the fingers will lead to co-contraction. Also, joint construction will cause the fingers to adduct when flexing. These factors will limit the potential hand span and increase muscle forces when playing if the pianist tries to flex/abduct the fingers at the same time. When playing, this can occur either when flexing the fingers from an abducted position, or vice-versa.	Urvater, 1995, Vol. 1, 3, 4, 5
7. Don't curl the thumb	Curling the thumb can be defined as actively flexing the interphalangeal joint (IP). This is done by contracting the flexor pollicis longus (FPL) muscle. The FPL is a multiarticular muscle, so IP flexion will require co-contraction to limit movement at the MCP joint. This will increase stiffness and muscle forces needed to move the thumb when playing.	Urvater, 1995, Vol. 1, 2

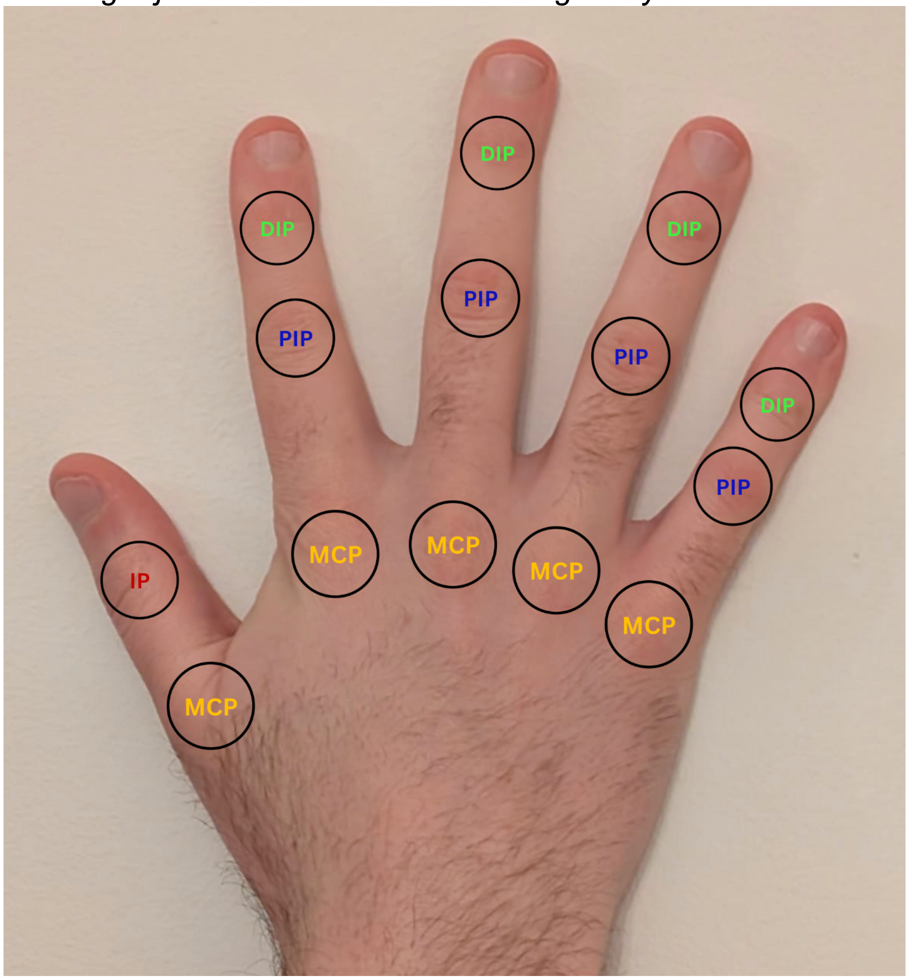
Note. Subcategory 1 was included in Sabo et al., 2023 as an example of how the methodology was employed.

1.1 Curling is pulling fingers in from the nail joint

TA summary. In the TA, curling is defined as pulling in the last phalange [sic] of the fingers from the *nail joint* (Taubman, 1984, pp. 145-146; Urvater, 1995, Vol. 1; Moran, 2008, p. 22).

Analysis: nail joint. The term "nail joint" refers to the most distal joint of fingers 2-5, which is equivalent to the distal interphalangeal (DIP) joint described in anatomical literature (Cael, 2011) (Figure 1).

Figure 1
The finger joints discussed in the curling analysis.



Note. Fingers 2-5: the metacarpophalangeal joints (MCP), the proximal interphalangeal joints (PIP), and the distal interphalangeal joints (DIP). Thumb: the metacarpophalangeal joint (MCP), and the interphalangeal joint (IP).

Pulling in. A demonstration of pulling in the nail joint (Urvater, 1995, Vol. 1) shows moving the distal phalanges of fingers 2-5 toward the palm by DIP joint rotation. The biomechanical term for this is DIP flexion. The words "pulling in" indicate that curling refers to actively flexing the DIP joints beyond their resting position (Figure 2). The statement that "any time we curl our fingers, we activate [the long flexor] muscle" (Urvater, 1995, Vol. 1) further suggests that curling involves active DIP flexion. Due to physiological constraints, flexing the DIP joints also causes some flexion at the proximal interphalangeal (PIP) joints, but this is not discussed in the included TA sources.

Figure 2

An example of flexing fingers 2-5 from the DIP joints (curling). Doing so also causes some additional flexion at the PIP joints.

Note. Reprinted from Sabo, 2021

1.2 Fixating causes dual muscular pulls

TA summary. TA sources discourage fixating, molding, or preparing the fingers in any way before playing because “fixating is usually achieved by the use of contrary muscles, such as flexing and extending at the same time” (Urvater, 1995, Vol. 1). *Dual muscular pulls* describes activating opposing muscles simultaneously, which pianists should avoid because it causes tension (Urvater, 1995, Vol. 1). Pianists are often taught to mold their fingers into a curled position before playing, which the TA discourages (Urvater, 1995, Vol. 1).

Analysis: Fixating, tightening, preparing, or molding. One likely aspect of fixating is placing the joint(s) in a state of rotational equilibrium. Because *tighten* is also used to describe this “muscular state of the fingers and hand” (Urvater, 1995, Vol. 1), it also likely refers to creating high resistance to rotation in any direction. In that case, the fingers would only be able to move a significant amount if a relatively high force were applied to them. Doing so would likely require using muscle contraction to create high levels of stiffness across the finger joints. The TA use of the term “preparing” likely means tightening the fingers in this way before playing. The term “molding” may describe creating stiffness after moving the fingers into a position outside of their resting position, which is also discouraged.

Dual muscular pulls and fixation/molding. TA sources state that simultaneously activating contrary muscles to fixate a joint creates dual muscular pulls. *Contrary muscles* likely refers to muscles that act to rotate a joint in opposing directions. The equivalent biomechanical term for an opposing set of muscles is antagonists (Freivalds, 2011, p. 49). Simultaneous activation of agonist and antagonistic muscles (Knudson, 2007, p. 284) is called coactivation or co-contraction. While the TA sources state that dual muscular pulls should be avoided altogether, some co-contraction is necessary for skilled movement, including piano playing (Ashkenazi et al., 2025). Still, expert pianists have been found to play using less co-contraction of finger flexor/extensor muscles than novices (Furuya et al., 2011). In this case, the call to avoid dual muscular pulls in the TA sources can therefore be understood as applying to co-contraction that is considered to be excessive or unnecessary for performing the task. Creating high levels of stiffness across finger joints to fixate or tighten them usually requires high levels of co-contraction. In doing so, muscles generate high forces pulling in opposite directions. If the forces pulling in both directions are equal (0 net force), the fingers do not move, but the muscles become stiff and increase joint stiffness. If fingers are fixated outside of their resting position (i.e., molding), more significant co-contraction will likely be needed to resist the muscles' tendency to return to resting length. However, this may not be true when finger(s) are contacting an outside surface (e.g., the piano), which can apply the necessary force to maintain joint position.

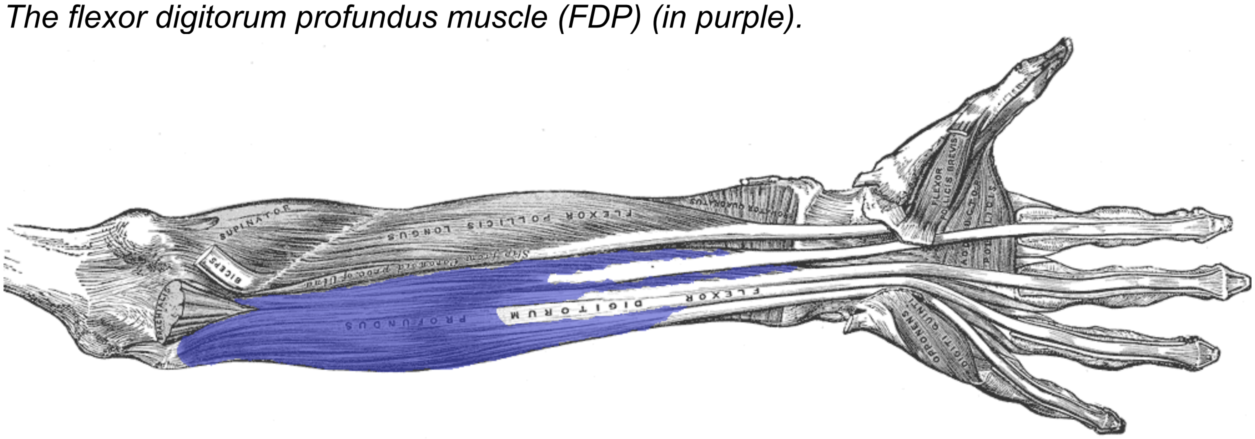
1.3 Curling uses the long flexor muscle that pulls tightly under the wrist/fingers

TA summary. The TA sources state that curling requires using the *long flexor* muscle, which is described as "extending from the tip of the fingers to the elbow" and "pulling tightly under the wrist and the fingers" (Taubman, 1984, pp. 145-146; Urvater, 1995, Vol. 1; Milanovic, 2012, p. 133).

Analysis: Long flexor. The flexor digitorum profundus (FDP) (Figure 3) is the only muscle that flexes the DIP joints, originates at the elbow, crosses the wrist and fingers, and attaches to the fingertips (Cael, 2011). The FDP matches Taubman's description of the long flexor more closely than the flexor digitorum superficialis (FDS) (Figure 4), which does not flex the DIP joints, but instead primarily flexes the PIP joints. Still, PIP flexion must also occur in conjunction with DIP flexion (subcategory 1.1), and activity in the FDP/FDS muscles is often coordinated during finger flexion tasks (Darling, Cole, & Miller, 1994). Therefore, while the TA sources only discuss one long flexor muscle, curling likely involves some activation of both muscles.

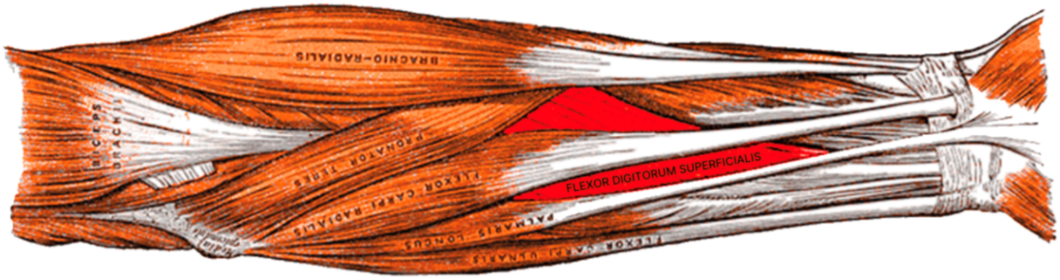
Figure 3

The flexor digitorum profundus muscle (FDP) (in purple).



Note. Adapted from Gray, 1918. Public domain.

Figure 4
The flexor digitorum superficialis muscle (FDS) (in red).



Note. Adapted from Gray, 1918. Public domain.

Pulls tightly. The FDP is a multiarticular muscle that crosses the wrist and three finger joints. Therefore, if the FDP contracts without resistance, it produces rotation at all these joints (Watkins, 2014). To stop those joints from rotating, at least one antagonist muscle must act as a *neutralizer*, (Watkins, 2014, p. 139; see p. 141 for a visual) by contracting to resist the force tending to cause that unwanted rotation. If a pianist contracts the FDP/FDS by flexing the DIP/PIP joints (curling), at least one antagonist muscle must contract to prevent the wrist and MCP joints from also flexing. The co-contraction needed to flex the DIP/PIP joints (curling) while maintaining the position of the wrist/MCP joints will generally increase stiffness across some or all these joints. Taubman's statement that the FDP (long flexor) pulls tightly across the wrist and fingers likely refers to this increase in wrist/finger stiffness. This effect would be exacerbated by the FDP's anatomy (Freivalds, 2011), which allows it to generate high levels of force and stiffness required for gripping tasks (Long et al., 1970).

1.4 Curling restricts up and down hand/finger motion

TA summary. TA sources state that because the long flexor pulls tightly, curling restricts or inhibits the *up and down* motion of both the hand and the fingers (Taubman, 1984, pp. 145-6; Urvater, 1995, Vol. 1; Milanovic, 2012, p. 133). This is demonstrated by asking audience members to curl their fingers and then try to move their fingers or hands up and down very quickly (Taubman, 1984, pp. 145-146; Urvater, 1995, Vol. 1). These movements are described as restricted, compared to when the fingers are in their *natural curve*.

Analysis: restriction of finger/hand motion. Restricted likely means that when the DIP/PIP joints maintain a flexed (curled) position, any forces acting to flex/extend the wrist and fingers encounter relatively high levels of resistance. Consequently, these movements require more muscle force, so they will have lower potential velocity and produce smaller movements. This may be due to increased finger/wrist stiffness created by co-contracting muscles (subcategory 1.3), which tend to keep the fingers/hand in their current position. To move the fingers/hand while the DIP/PIP joints remain flexed, the muscles used to execute those movements will need to generate enough force to both overcome the stiffness and execute the task. Force and velocity have an inverse relationship (Knudson, 2007, p. 80), so increasing force will decrease the potential velocity of the finger/hand movements. Co-contraction and increased force will also activate more (and larger) motor units, making movements jerkier, less precise, and less efficient (McLester & St. Pierre, 2007), ultimately limiting one's ability to play accurately and control tone production.

1.5 Curling prevents opening the hand

Categories 1.5 and 1.6 discuss the relationship between curling the fingers and *opening* (Urvater, 1995, Vol. 3) or *stretching* (Urvater, 1995, Vol. 1) the hand/fingers. Analyzing these categories required similar biomechanical concepts, so both categories are analyzed together after the summary of subcategory 1.6.

TA summary. TA sources claim that curling makes it very difficult to "open the hand and the fingers," "makes playing distances a problem," and results in a "limited hand span" (Urvater, 1995, Vol. 3, 5). This can occur when starting with a curled position and trying to open the hand to play distances (Urvater, 1995, Vol. 3), and when curling the non-playing fingers while trying to maintain an open hand position (Urvater, 1995, Vol. 5).

1.6 Curling and stretching together creates dual muscular pulls

TA summary. TA sources state that attempting to stretch and curl the fingers at the same time is problematic because it activates opposing muscles (Urvater, 1995, Vol. 1, 4). This occurs because curling is achieved by activating flexor muscles, while opening the hand/stretching is achieved by activating extensor muscles and "abductors, which are forms of extensors" (Urvater, 1995, Vol. 1). This combination of flexion/extension is an example of dual muscular pulls, which causes tension (Urvater, 1995, Vol. 1). Simultaneously curling and stretching the fingers before playing is described as a "very, very tight position." Taubman describes the look of the hand and fingers in this state as "making claws" (Urvater, 1995, Vol. 1).

Analysis: Open the hand/fingers. Opening the hand and fingers refers to finger abduction, which only occurs by rotating (*spreading*) the fingers about the MCP joints in the coronal plane (Cael, 2011). The statement that curling makes it difficult to open the hand likely means that it is difficult to abduct the fingers while maintaining a flexed position at the DIP/PIP joints.

Limited hand span. TA sources state that DIP/PIP flexion (curling) limits one's ability to abduct the fingers and "limits hand span," particularly in octave playing (Urvater, 1995, Vol. 5). Hand span is typically measured as the distance between the tips of the thumb and the small [fifth] finger (Sakai et al., 2006, p. 831). TA statements that curling limits hand span or makes it impossible to open the hand indicate that because DIP/PIP flexion (curling) limits one's ability to abduct the fingers, it therefore decreases the maximum distance that one can create between the thumb and fifth finger.

Stretching. TA sources state that combining DIP/PIP flexion (curling) and stretching is problematic. In this context, the term "stretching" likely refers to abducting (spreading apart) the fingers at or close to the end of their range of motion.

Playing distances. TA sources also state that because DIP/PIP flexion (curling) limits hand span, it "mak[es] distances a problem" (Urvater, 1995, Vol. 3). This likely means that it is difficult to play consecutive notes that are far apart on the keyboard.

Flexion and abduction create dual muscular pulls. Opening the hand requires abducting all five fingers simultaneously. This would activate all the abductor muscles, which also act to extend the fingers. The force generated by the FDP/FDS to flex the

DIP/PIP joints would resist the force generated by the abductors to abduct/extend the fingers. As a result, trying to simultaneously maintain a flexed DIP/PIP position while abducting the fingers (opening the hand) would require substantial co-contraction (dual muscular pulls) and increase stiffness across the finger joints. The abduction movement will only occur if the abductors generate enough force to resist that caused by the flexors (McLester & St. Pierre, 2007). The problem of simultaneously curling and stretching is exacerbated by the ligaments and bones connecting at the MCP joints, which cause the fingertips to come together (finger adduction) as they flex and will decrease the amount of abduction that can be achieved.

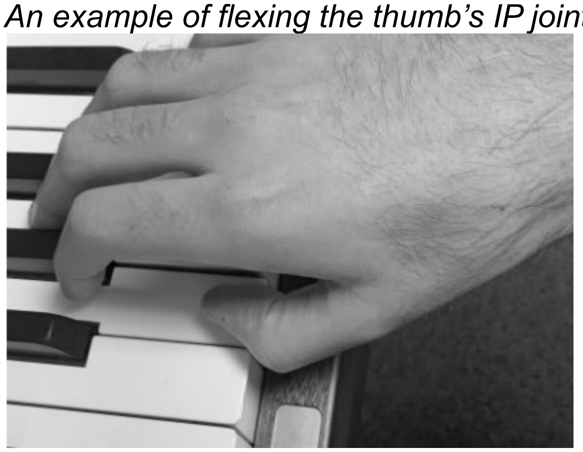
1.7 Don't curl the thumb

TA summary. In addition to advising against curling fingers 2-5, TA sources also discourage curling the thumb (Urvater, 1995, Vol. 1).

Analysis: curling the thumb. Unlike curling fingers 2-5, the term "curling" when applied to the thumb is not explicitly defined within TA sources used for this study. For fingers 2-5, curling refers to DIP joint flexion, which also causes PIP joint flexion (see subcategory 1.1). A demonstration of curling the thumb (Urvater, 1995, Vol. 1) indicates that curling similarly refers to flexing the thumb's interphalangeal (IP) joint. As with curling fingers 2-5, the TA sources do not define curling the thumb as simply having any amount of flexion, but rather as actively flexing the thumb beyond its resting position (Urvater, 1995, Vol. 1). A demonstration (Urvater, 1995, Vol. 1) suggests that most of the flexion occurs at the IP joint, with a small degree of flexion possibly occurring at the MCP joint.

Figure 5

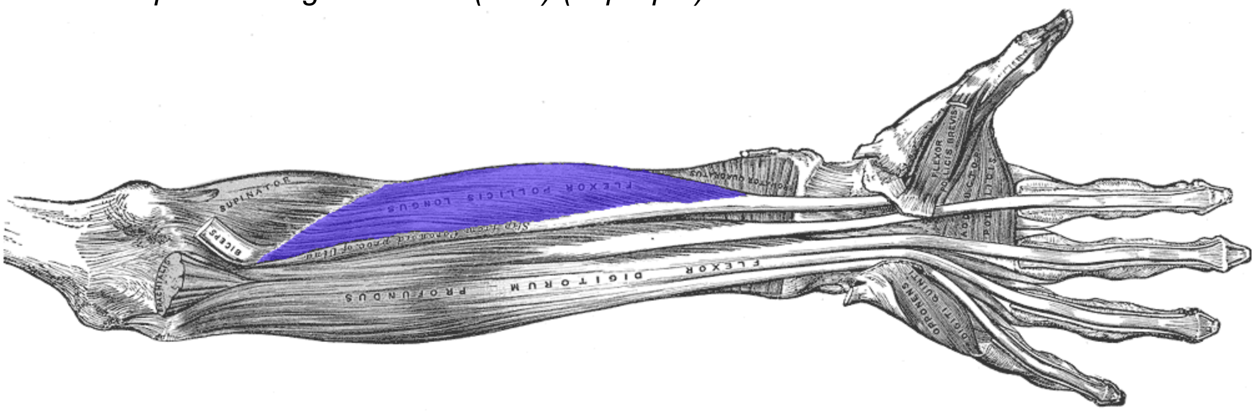
An example of flexing the thumb's IP joint (curling the thumb).



Note. Reprinted from Sabo, 2021.

Muscles involved in curling the thumb. The curled thumb position demonstrated in the TA requires activating the flexor pollicis longus (FPL) (Figure 5) to flex the thumb's IP joint (Figure 1). The FPL also crosses the thumb's MCP joint (Figure 1), so depending on the exact curled position, some co-contraction may also occur to prevent MCP joint flexion. This would likely be done by the extensor pollicis brevis (EPB), which acts to extend the thumb at the MCP joint. The extensor pollicis longus (EPL) may also contract to keep the IP joint in equilibrium. Activating all these muscles (the FPL, EPB, and EPL) to bring the thumb into a state of equilibrium outside of its resting position would constitute another form of "molding" as described by the TA (subcategory 1.2). As such, it would increase co-contraction and stiffness across the thumb joints.

Figure 6
The flexor pollicis longus muscle (FPL) (in purple).



Note. Adapted from Gray, 1918. Public domain.

Category 2: Curling leads to physical/musical problems

The second main category focused on physical and technical problems that the TA associates with curling. Table 2 provides pedagogical and biomechanical definitions for each subcategory.

Table 2
Curling leads to physical/musical problems

Subcategory	Biomechanical analysis	TA sources
1. Curling / fixating creates tension/tightness	The sustained muscle co-contraction caused by actively flexing the DIP/PIP joints may cause the muscles involved to become overworked. This may also increase joint stiffness and make it difficult to move when playing.	Urvater, 1995, Vol. 1, 3, 5; Moran, 2008; Milanovic, 2012
2. Curling can lead to pain / injury	Maintaining active DIP/PIP flexion when playing the piano can lead to sustained muscle co-contraction. If continued for a long enough period of time, this may lead to muscle fatigue, spasm, numbness, and pain. If this activity is continued, a chronic muscle disorder or injury to other soft tissues (e.g., tendons) may result.	Taubman, 1984; Urvater, 1995, Vol. 1, 3; Moran, 2008
3. Curling can cause fingers to stay curled / dystonia	Sustained muscle co-contraction may lead to musician's focal hand dystonia, a neuromuscular condition in which leads to reduced voluntary control of individuated finger movements and involuntary movements or cramping in other, non-playing fingers. This may occur due to repetitively co-contracting finger muscles needed to play with DIP/PIP flexion, but more research is needed.	Urvater, 1995, Vol. 1, 3

4. Miscellaneous problems associated with curling	Several other problems were considered outside the scope of this study: *mixed messages*, a *crammed feeling*, *cramping*, *clenching*, *limitation*, and *hindered memory*.	Urvater, 1995, Vol. 1, 3; Milanovic, 2012

2.1 Curling/fixating creates tension/tightness

TA summary. The TA states that “curling leads to tension and tightness (Urvater, 1995, Vol. 1). The widespread use of these terms to describe curling in many contexts (when the wrist is low, when fixating the fingers, when playing octaves, etc.) indicates that tension/tightness are produced when curling at any time.

Analysis: Constant pull. Maintaining a curled position (DIP/PIP flexion) while playing piano requires continuously activating the FDP muscle and possibly the FDS muscle (see subcategory 1.3). It will also lead to co-contraction of finger extensors (see subcategory 1.3). Taubman states that this “constant pull will be exacerbated when power is needed,” suggesting that as the pianist tries to depress the key with more force/velocity to create louder sounds, the finger muscles will need to generate even more force to overcome the resistance created by the co-contracting muscles.

Tension/ tightness. Wheatley-Brown et al. (2014) found that the term “tension” is always used in the TA with a negative connotation, which is inconsistent with its biomechanical definition. TA sources suggest that dual muscular pulls, is synonymous with tension, which “limit[s] motion” (Urvater, 1995, Vol. 1). Tension is contrasted with moving “properly and freely,” in which “one muscle is active, and the opposing muscle has to be passive” (Urvater, 1995, Vol. 1). Additionally, tension is stated to arise “from overusing the muscle” (Urvater, 1995, Vol. 1). These statements suggest that the TA uses this term to describe: 1) co-contracting muscles to increase joint stiffness, and/or, 2) contracting a muscle to a high degree relative to its total capability. Curling as a cause of tension in both definitions is consistent with the findings in category 1. The TA sources seem to use the terms “tension” and “tightness” interchangeably. For example, they state that when curling as a starting hand position, “you’re already starting with this kind of a very, very tight position. This produces tensions even before one begins to move” (Urvater, 1995, Vol. 1).

2.2 Curling can lead to pain/injury

TA summary. Some TA sources state that curling can cause pain and injury. In some contexts, these statements are made generally, without specifying the type of injury or the location of pain (Urvater, 1995, Vol. 1, 3). TA sources suggest that curling is associated mainly with muscular pain/injury (Taubman, 1984, p. 146). Taubman states that the “constant pull” caused by curling can cause the muscles to “weaken and spasm,” which will lead to “numbness, clenching, and pain.”

Pain/injury. The TA sources do not clearly distinguish between pain and injury. These two concepts are often linked in scientific literature, with pain as a symptom of a particular disorder (Narducci, 2020). Pain is sometimes classified into types depending on its underlying mechanisms and subjective presentation (Mense, 2008). Because Taubman links curling with repetitive and sustained muscle contraction, it is possible that she associates it with a form of muscle pain/injury. Muscle injuries often “start as simple muscle soreness or pain...because of microstrain and inflammation of the tissue”

(Freivalds, 2011, p. 205). If the harmful activity is continued, the injury can become chronic, with symptoms of spasm, dysfunction, or temporary disability (Freivalds, 2011). Many such symptoms overlap with those described by Taubman in relation to curling. The injury ascribed to curling may therefore refer to a chronic muscle condition occurring from "sustained high levels of playing or sudden increases in playing burden" (Narducci, 2020, p. 199). However, musicians' overuse injuries more commonly affect other soft tissues (Narducci, 2020), so the injuries ascribed to curling may also occur in another tissue (e.g., tendons attaching extrinsic finger muscles to bones).

Fatigue/weakness. One possible cause of muscle fatigue is sustained muscle contraction, which causes high levels of intramuscular pressure and limits blood flow to the muscle (Freivalds, 2011). If the muscle contractions needed to flex the DIP/PIP joints are sustained for enough time without rest, the muscles will have decreased force production capability. However, Taubman's (1984) description of both *fatigue* and *weakness* as separate symptoms suggests that she uses the term "fatigue" not in a strict biomechanical sense, but in the more colloquial sense of feeling tired, and the term "weakness" to mean reduced force production capability.

Spasm. Like fatigue, muscle spasm is often thought to be caused by insufficient blood flow to the muscle (i.e., ischemia) (Mense, 2008, p. 217). Pain caused by muscle spasms can range from low to very high depending on their severity and cause.

Numbness. Numbness refers to a loss of feeling, which is sometimes accompanied by tingling sensations. Numbness is more commonly a symptom of nerve entrapments, which may sometimes occur due to sustaining abnormal joint positions when playing (Rosenbaum et al., 2015).

2.3 Curling can cause fingers to stay curled/dystonia

TA summary. The TA sources state that if pianists play regularly with curled fingers, eventually the fingers can "stay curled" or "clench" to the point that the pianist will not be able to open them anymore (Urvater, 1995, Vol. 1, 3). They refer to this condition as *dystonia*.

Analysis: Stay curled/dystonia: The term "dystonia" has a long history and has been used to describe a wide variety of conditions (Newby et al., 2017). More recent scientific literature describes musicians' focal hand dystonia (MFHD; sometimes known by other, related names) as a neurological disorder that can result in reduced voluntary control of individuated finger movements and therefore negatively impact pianists' ability to control the speed and timing of key depression (Furuya & Altenmüller, 2013). MFHD also commonly leads to involuntary movements or cramping in other, non-playing fingers (Furuya et al., 2015). For some, this can involve involuntary co-contraction of antagonist muscles, very often flexor/extensors of fingers/hand, which produces a hyperflexed or hyperextended position when playing (Catellani et al., 2024). More research is needed to fully understand the etiology of MFHD, which is thought to be complex (Comoletti & Mercogliano, 2024). Still, the symptom of involuntarily flexed fingers in some pianists with MFHD should be considered distinct from the activity of curling described in the TA. The TA sources do not explain why Taubman believed regularly engaging in DIP/PIP flexion while playing (curling) may lead to dystonia, and these statements are likely based on her experience working with affected pianists. One possible explanation is that the repetitive or continuous co-contraction required to maintain DIP/PIP flexion in piano playing may lead to the brain changes associated with dystonia that eventually cause these muscles to co-contract every time the person plays. However, more research is required to investigate these claims, which have not been scientifically validated at the time of publication.

2.4 Miscellaneous problems associated with curling

TA summary. In addition to the issues described above, the TA sources describe several other problems that may result from curling. These include: “mixed messages” from trying to simultaneously “fixate and move the fingers” (Urvater, 1995, Vol. 1); a “crammed feeling;” “cramping” or “clenching” (Urvater, 1995, Vol. 1, 3); and difficulties memorizing a piece (Milanovic, 2012, p. 126). These issues are primarily neurological or psychological, rather than biomechanical, and were therefore not analyzed in detail.

Discussion

Findings of this study can provide teachers with insights into both the Taubman Approach and the biomechanics of piano playing. Helping students develop efficient and healthy technique is considered an extremely important aspect of piano pedagogy, but it is highly complex and not always well understood by teachers (Crappell, 2019). Pianists and teachers are often confronted with conflicting information about the best approach and may not necessarily have the scientific background required to understand the biomechanical implications of different approaches. The topic of curling discussed in this paper relates to fundamental issues of finger position and movement, which are often taught to students from the onset of piano instruction (Goebl & Palmer, 2013). Pedagogical terminology on this topic is generally diverse, with some approaches using terms such as curving, curling, or metaphorical instructions to describe various finger positions that pianists should or should not adopt (Milanovic, 2012). Taubman (1984) contrasts curling, which she considered problematic, with the natural curve, which she considered correct. The distinction between these terms and their biomechanical implications was explored in this study and will be discussed in a future publication to provide greater context to the findings presented here. The findings here may help teachers better understand what Taubman meant by curling and why she considered it to be problematic. Additionally, the language provided here may help teachers who wish to teach their students appropriate anatomical and biomechanical concepts underlying their pedagogical choices. Finally, despite the challenges of directly identifying biomechanical causes for certain injuries, findings may be useful to pianists and teachers attempting to alleviate problems that may be related to curling. While this subject requires further research, this translation may assist in promoting more informed and productive interdisciplinary discussions about the topic of curling and the relationships among different pedagogical approaches.

Limitations and further research

This study aimed to explain Taubman’s ideas using modern scientific language. Because scientific authors do not always agree on terminology (Reeves, 2005), we did not seek to produce a single, authoritative set of language related to curling; rather, translations were designed to assist further study and discussion among teachers, researchers, and health practitioners. Also, the analysis focused on biomechanics, rather than motor control. Because pedagogical language is often mediated by experience, aspects of motor control may significantly impact the words used to describe an experience and therefore their meaning. Our method focuses on translation (Sabo et al., 2023) and did not seek to fully evaluate the TA's claims about curling, which requires further research. This line was sometimes difficult to navigate, as we did include biomechanical aspects of curling that were not explicitly included in the TA sources (e.g., that it likely includes PIP flexion/FDS activation in addition to DIP flexion/FDP activation). Biomechanical studies suggest that finger position significantly impacts internal and external forces when playing, which may impact injury occurrence (Nakamura et al., 2013; Furuya & Kinoshita, 2008; Harding et al., 1993; Wolf et al., 1993). However, no studies have explicitly examined how these factors are affected by curling as defined in the TA. The translations here may help clarify pedagogical terminology to facilitate such studies.

Additionally, translation relies on the authors' expertise and is therefore somewhat subjective. Subjectivity was unavoidable under our methodology, but it was mitigated by consulting scientific and pedagogical experts. Further nuances in meaning could likely be identified by consulting additional experts or TA sources. This article is the first published example of how this methodological framework (Sabo et al., 2023) can translate pedagogical language into scientific language. Future studies may apply this method to other pedagogical approaches. Doing so would allow for evaluating ideas from various approaches, both in comparison to scientific literature and to one another. Previous studies have compared Taubman's ideas to those of other teachers and/or scientific literature (Takamizawa & Kenway, 2023; Wheatley-Brown et al., 2014), but these studies have not explicitly engaged with potential language issues. Not doing so makes it unclear if differences between sources are due to linguistic choices or substantive differences in meaning. Future investigations could incorporate translations like those above to reduce potential confusion and allow for more effective transfer of knowledge between disciplines. Without common terminology, substantive discussions of that kind can be challenging, so studies built on this model can benefit both teachers and researchers.

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