# The Effects of Heel Height on Head Position, Long-Term Average Spectra, and Perceptions of Female Singers

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**Summary:** Female singers often wear high heels for auditions and performances. Heel height research in non-singing contexts indicates that wearing heels can affect body alignment and head position. Studies in orthodontics, sleep apnea, and voice science suggest that head and neck positioning can alter the vocal tract. The purpose of this study was to assess the effects, if any, of heel height (barefoot, 10.16-cm stilettos) on three angles of singer head position (calculated from C7–tragus–nasion), long-term average spectra data, and perceptual data (questionnaire) acquired from female ($N = 30$) soloists during alternating periods of silence and singing. Results indicated that all participants (100%) significantly decreased head position angle measurements (inferior and posterior head and neck movement) when singing in high heels compared with singing barefoot. Participants, on average, significantly increased head position angle measurements (superior and anterior head and neck movement) when singing compared with standing silently, and did so to a greater degree when transitioning from silent heels to singing heels compared with transitioning from silent barefoot to singing barefoot. Long-term average spectra data indicated significant spectral energy differences between barefoot and high heel singing conditions across participants. Most participants ($n = 21$, 70.00%) indicated they felt comfortable and sang their best while barefoot. Results of this study, the second in a series of experiments addressing the effects of shoe heel height on female singers' vocal production, were discussed in terms of application to vocal pedagogy and directions for future research.

**Key Words:** Head position–Singing–Heel height–Posture–LTAS.

Voice professionals routinely offer anecdotal advice concerning shoes that female singers may wear for auditions and performances. Eichhorn-Young favors wearing high-heeled shoes for auditions and performances and asserts, "Flats make you look like you have stove pipes for legs and generally make you stand like a duck."[1] del Santo comments, "Ladies should wear a pair of pumps with a heel of comfortable height. (Remember that posture affects your voice!) Avoid open-toed sandals or boots with thick heavy heels."[2] Laryngologists state that high heels may negatively impact the voice and advise singers to wear half-heels or flats.[3,4] The literature reveals mixed opinions regarding singer head position. Some voice pedagogues recommend that singers maintain a level head position when singing,[5–7] whereas others advise singers to use a slightly elevated or slightly lowered head position.[8,9]

Studies in non-singing contexts have documented numerous effects associated with wearing high-heeled shoes, including (1) injuries, pain, and deformities[10–13]; (2) modifications in gait patterns[14–16]; (3) neck and muscle fatigue[17–19]; (4) increased likelihood of an ankle sprain or break[20,21]; (5) increased chance of a slip or fall[22,23]; (6) increased oxygen consumption and heart rate[21,24]; (7) alterations in mean center of gravity[19,25–28]; and (8) muscular compensation.[29] In 1994, Thompson and Coughlin estimated that the yearly American healthcare costs related to high heels exceeded 3 billion dollars per year.[30]

A sizeable number of studies have measured the effects of heel height on the body alignment of females in the general population and found alterations in lumbar lordosis[25,31–37] and knee flexion.[18,38] Fewer studies on the effects of high heels on head position have indicated that high heels triggered a posterior displacement of the head in some participants,[29] and that out of multiple postural angles analyzed, only head position differed significantly between all heel type conditions (barefoot, stiletto, platform) and experience groups (occasional [$M = 50.73°$] and frequent heel wearers [$M = 53.13°$]).[39]

Investigations within the fields of orthodontics and sleep apnea have found that a change in head position affects multiple elements of the vocal tract, including (1) trachea length,[40] (2) position of the hyoid bone,[41–44] (3) pharyngeal airway space,[42,45–48] and (4) position of the tongue.[49] Several studies have established a relationship between jaw opening and head position[50–54] and indicated that maximal mouth opening required a concomitant posterior movement of the head.[43]

Studies with singing participants have indicated that (1) head position exhibited a significant elevated and forward movement when singing compared with baseline silent measurements,[55] (2) alterations in head position occurred as pitch ascended,[56,57] (3) professional singers displayed cervical spine abnormalities whereas naïve singers did not,[56] and (4) positive, moderate correlations existed between vocal structures, the craniofacial skeleton, and the cervical spine.[58] Scotto Di Carlo[56] theorized that the amount of singer jaw opening determined the degree of head elevation and posterior movement of the cervical spine; however, Miller et al[57] removed the confounding variable of jaw opening by having singers hum lower to higher pitches and found that singers still exhibited an increase in craniocervical angle measurements. In a subsequent study, Scotto Di Carlo[59] found that a female singer, with calcification of the laryngeal cartilage, used a lowered head position to help with the tilting of the thyroid cartilage needed to sing higher pitches. Due to this

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interconnectedness, singers should be cautious when considering cervical spine surgery.[55]

In a head repositioning experiment based on the Alexander technique, Jones[60] manually pulled up on the cranial skull base of one female participant and found improved integrity of vocal harmonics on spectrographic analysis. Luck and Toiviainen[61] conducted a pilot study exploring the effects of 14 kinematic postural elements on the vocal timbre of singers ($N = 15$). The results indicated that head and upper body positioning produced the greatest differences in voice quality. When singers positioned the head down, spectral irregularity (noise) increased. When singers tilted the head up, an increase in the root-mean-square (RMS) amplitude occurred, which the researchers hypothesized came from a freeing up of the vocal apparatus that permitted greater airflow.

A limited number of perceptual listener studies have been completed using singers with altering or altered head positions. Barnes-Burroughs et al[62] found that a classical voice pedagogue listener consistently favored the tone quality of the singer performing in a downcast head position or in an inverted melodic contour posture (with head elevation as pitch descended and head lowering as pitch ascended), whereas a musical theatre voice pedagogue listener demonstrated idiosyncratic preferences and favored the elevated head posture in some participants. Rollings[63] asked a soprano ($N = 1$) to sing a portion of an aria in lowered, neutral, and elevated head position conditions prompted by changes in focal point. University music majors ($N = 30$) listened to randomized pairs of the singer performing in these conditions and, on average, preferred the recordings of the soprano singing in the neutral head position condition, followed by the lowered and then elevated head position conditions. The mean long-term average spectra (LTAS) data from the singer indicated that the lowered head position reduced the mean signal amplitude, and the elevated head position increased the mean signal amplitude. The amplitude of individual harmonics deviated as much as 5.75 dB.

Only one study to date has examined the effects of high heels on postural, acoustical, and perceptual measures of female singers. In a collective case pilot study, Rollings[64] studied female voice majors ($N = 5$) at different levels of vocal study as they performed a participant-selected aria and wore three different pairs of their own shoes, each in a different heel height range (low [<1.27 cm], medium [2.54–6.35 cm], and high [>6.35 cm]). The participants evidenced postural changes in head position, lumbar lordosis, and knee flexion between each of the three heel height conditions. Head position measurements yielded the most change in postural alignment, as four of the five participants sang with a lowered head position when wearing the high heels compared with the low heels. Acoustically, LTAS data from four of the five participants displayed significant differences between low and high heels. Perceptually, some of these singers ($n = 3$) believed that heel height could impact how comfortable they felt in a performance, but no singer mentioned that it might affect vocal production. Four singers preferred the medium heel height (2.54–6.35 cm) for singing. This case study utilized varying repertoire and heel heights with a small number of singers.

The purpose of the present study was to assess the effects, if any, of heel height (barefoot, 10.16-cm stilettos) on three angles of singer head position (calculated from C7–tragus–nasion), LTAS, and perceptual data (questionnaire) acquired from female ($N = 30$) soloists during alternating periods of silence and singing. The following research questions guided this investigation:

(1) Are there significant differences in the three angles of participant head position measurements between heel height (barefoot, 10.16-cm stilettos) and behavior (silent, singing) conditions?
(2) Are there significant differences in LTAS data between participants' singing barefoot and singing in 10.16-cm high-heeled shoes?
(3) What do participant questionnaires suggest about participants' perceived comfort level and ability to sing efficiently in barefoot and 10.16-cm high-heeled conditions?

## METHODS

### Participants

A convenience sample of female singing participants ($N = 30$) from a university school of music ranged in age from 17 ($n = 1$) to 29 ($n = 1$) years ($M = 21.30$ years, standard deviation [SD] = 3.13 years). Each participant declared music as her major and voice as her primary instrument (voice performance [$n = 10$], music education [$n = 7$], and music therapy [$n = 13$]). Participants included undergraduate (freshman [$n = 7$], sophomore [$n = 10$], junior [$n = 2$], senior [$n = 2$]), and graduate (master's [$n = 8$], doctoral [$n = 1$]) students.

### High heels

All participants wore a pair of Vivian Pointy Stiletto heels manufactured by Mossimo and sold by Target stores for the high-heeled condition (Figure 1). The outsole material of the heels consisted of 100% thermoplastic rubber. The participants chose the most comfortable pair of heels to use from all available shoe sizes (6.0, 6.5, 7.0, 7.5, 8.0, 8.5, 9.0, 9.5, and 10.0). Heels (sizes 7.0–9.5) measured a height of 10.01 cm with no platform. The smallest and largest sizes had slightly lower and higher heels

**FIGURE 1.** 10.16-cm Vivian Pointy Stiletto heels by Mossimo.