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Expert-novice difference in string clamping force in violin playing

Hiroshi Kinoshita,[1] Satoshi Obata[1], Takeshi Hirano[1], Chie Ohsawa[1], and Taro Ito[2]

[1] *Biomechanics & Motor control lab, Graduate School of Medicine, Osaka University, Osaka, Japan*
[2] *Department of Health and Sports Science, Mukogawa Women's University, Hyogo, Japan*
[1] hkinoshita@moted.hss.osaka-u.ac.jp

ABSTRACT

Difference in the nature of force for clamping the strings between expert (N = 8) and novice (N = 8) violin players was investigated using a violin installed with a 3D force-transducer, and produced sound. These players performed repetitive open A- and D-tone (force measurement) production using the ring finger at tempi of 1, 2, 4, and 8 Hz at *mezzo-forte*. At 2- and 8-Hz tempi, the same task was performed by the other fingers. At 1 and 2 Hz, the profiles were characterized by an initial attack force, followed by a leveled force during the finger contact period. The peak attack force for the experts exceeded 5 N, which was significantly larger than about 3.N for the novices. At 4 and 8 Hz, only attack force with a lower peak with no group difference was observed than at the faster tempi, but attack-to-attack variability of force was significantly larger for the novices than the experts. Both the experts and novices had a lower attack force by the ring and little fingers than the other two fingers, but the finger difference was much less for the experts. The findings suggest that expert violinists use a strategy of trade-off between physiological cost of string clamping force and production of high quality sound. High consistency of attack force action is also an important

Background

When playing bowed string instruments such as the violin, viola, cello, and double bass, the left fingers press the string against the fingerboard to temporarily shorten the string in order to control sound pitch. During this string-pressing motion, the fingers undergo string and fingerboard reaction (string clamping) forces. The former is generated by the tension of the string, and the later is the additional force applied by the finger to press and stabilize the string onto the fingerboard. Earlier, we developed a violin installed with a 3-D miniature force transducer (Tek Gihan, Kyoto, Japan) on a portion of the neck to measure string clamping force at the D-note position below the A string [1]. Using this violin, we investigated the effects of playing tempo, dynamics (loudness), and finger in professional/semi-professional violinists. It was found that the force profiles were clearly tempo- as well as dynamics-dependent. The peak, average and impulse of the clamping force was greater during louder tone production at slower tempi. The index or middle finger had greater force compared to the ring or little finger.

Aims

In the present study, we investigated the expert-novice difference in the nature of the string clamping force as a kinematic variable for players control during violin playing. Information concerning the string clamping force can help in teaching novices about the magnitude and timing of appropriate string stabilizing action during sound production. The clamping force can also be linked to the magnitude of mechanical stress to which the players' left hand is constantly exposed. Neuromuscular and skeletal disorders in violinists and violists are found twice as often in the left than in the right hand [2]. Information regarding this stress could thus help in understanding the etiology of playing-related problems.

Methods

Eight expert (>14 years of training) and eight novice (<2 years of training) violin players formed two skill-level groups of subjects. The same violin from our previous study [1] was used to collect string clamping force by the left hand during playing repetitive A (open string) and D (force recording) tone production task. (Figure 1)

Figure 1. The violin with a 3-D force transducer

The task was performed at each of the five predetermined levels of musical tempi (1, 2, 4, and 8 Hz) and at a medium sound pressure level (*mezzoforte* = 75-77 dB) by the ring finger. At 2 and 8 Hz tempi, other three fingers were used to test the effect of finger. All tones were played without vibrato and with continuous slow upward and downward bow strokes. From the recorded three directional component forces (Fz, Fy, and Fx in Figure 1), the resultant force vector was calculated. This force vector was used as the string clamping force. Sound data were also measured using a sound level meter placed 1 m from the violin. The force and sound data from 20 successive tone production trials were stored on a PC sampling at a frequency of 2 kHz. The initial peak (attack) force, mean force, and impulse during the period of force application were computed from each clamping action. Statistical comparisons were made using ANOVA with repeated measures with $p<0.05$.

Results & Discussion

Figure 2 shows typical string-clamping-force recorded at 1- and 8-Hz tempi from one of the expert and novice players. At the slow tempo of 1 Hz, the force curve in experts showed an initial pulse with a distinct peak, which was followed by a leveled force at a submaximal magnitude. This leveled force lasted until near the end of the duration of the target tempo. At the tempo of 8 Hz, the force curve showed a single-pulse pattern. Force curves in novices showed a clearly lower attack force with larger inter-trial variability of the force history curves.

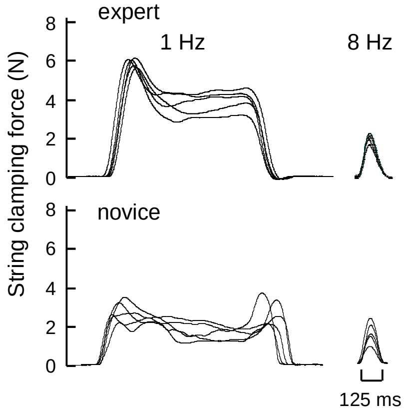

Figure 2. Examples of the string clamping force records from consecutive 5 tone productions performed by an expert and a novice. The finger used was the ring finger.

Figure 3 shows the group means of attack force at 1-, 2-, 4-, and 8-Hz tempi. At slow tempi of 1 and 2 Hz, string clamping force was around 3 N for the novices, and 5 N for the experts. At fast tempo of 8 Hz, the force was around 2.5 N for both groups. ANOVA revealed significant effects of group x tempo interaction ($F_{3, 42}$ = 4.96, p = 0.005), and tempo ($F_{3, 42}$ = 16.90, p<0.001). The interaction occurred because only at slower tempi of 1 and 2 Hz, the experts had a larger attack force value than the novices. The mean force and impulse values also had similar statistical results. The use of a stronger clamping force during relatively slow tone production by the experts was also found for the other fingers.

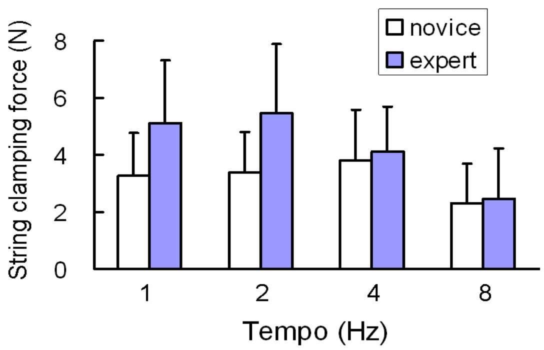

Figure 3. Effect of tempo on mean attack force for the expert and novice groups. Vertical bars indicate SD values. The finger used was the ring finger.

Figure 4 shows the effect of finger on the mean attack force for each group. The clamping force was weaker for the ring and little fingers compared to the index and middle fingers for both groups. The mean values of the novices were smaller for all fingers than the experts. The group effect was, however, significant only for the 2-Hz data ($F_{3, 42}$ = 4.67, p = 0.05). The finger effect was significant for the results at 2-Hz ($F_{3, 42}$ = 10.38, p<0.001), and 8-Hz ($F_{3, 42}$ = 11.08, p<0.001). Group x finger interaction was insignificant for both the 2- and 8-Hz data. Similar statistical results were found for the mean force and impulse data.

These findings indicate that experts use much stronger force for clamping the strings by all fingers than novices during

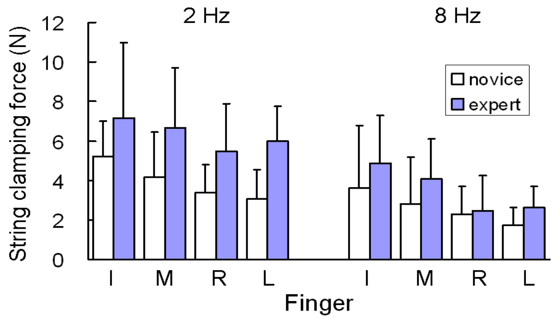

Figure 4. Effect of finger on mean attack force for the expert and novice groups. Vertical bars indicate SD values. I = index finger, M = middle finger, R = ring finger, and L = little finger

producing a tone at relatively slow tempi. This finding somewhat contradicts with the widely held belief among the string instrument educators that novices clamp the fingerboard so firm that they worn out easily. Our data clearly indicate that novice players are not clamping, or unable to clamp the strings firm. Probably griping the fingerboard with strong finger flexion force while the hand is held in an unnaturally curled (markedly supinated) position is a quite rare maneuver for anyone except for those started the violin/viola training at young age. The use of a strong force undoubtedly leads to fatigue of the hand muscles, and thus it can be less efficient. On the other hand, a sharp and strong attack force can provide a fast and clear tone transition [1]. A firm grip of the string on the fingerboard may also ensure higher quality of sound than a loose grip. Experts thus seem to use a strategy of trade-off between physiological cost and the quality of generated sound. It is also possible to postulate that with years of training, expert musicians, like marathon runners, should gain a high cost-performance ratio in physiological function of their hand muscles [3]. Thus, their physiological cost may be much less than that of the novices. At fast tempi with required rapid clamping action, the use of such strategy seems to be difficult even for experts.

Conclusions

Expert violin players used a stronger string clamping force for all fingers than the novice players at relatively slow tempi. Experts appear to use a strategy of physiological cost – sound quality trade-off. At faster tempi, the skill-level difference in the string clamping force was disappeared due to low maneuverability of clamping action.

Keywords

Novice, string clamping force, singer, violin, sound, expertise

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