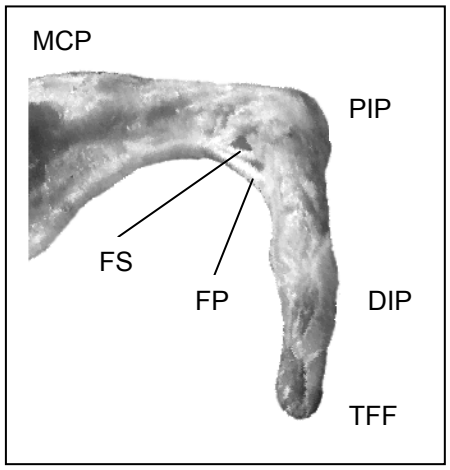
A DYNAMOMETRIC ANALYSIS OF PIANO PLAYING

Hartmut Riehle, Reiner Fritsch, Henriette Gärtner,
University of Konstanz, Germany

KEY WORDS: loads on the finger joints, mountain climbing, piano technique, dynamometry, cinematography, traumatology

INTRODUCTION: Damage to the tendons, tendon sheaths and finger joints are among the most common overuse injuries suffered by amateur mountain climbers (Hochholzer and Eisenhut, 1993). Chronic and recurrent micro-traumas resulting from static loading, among other causes, can cause paratendonitis, tendovaginitis, tendosynovitis and arthrotic degeneration of the finger joints. Research may show that the ring finger is the part of the hand most frequently damaged by such overuse.
Burtscher and Jenny (1987) found, in a study of 45 amateur mountain climbers, that 28.9% of the distal interphalangeal joints (DIP) and 17.8% of the proximal interphalangeal joints (PIP) were injured due to overburdening in climbing.



1a 1b

Fig. 1a: Representation of the digital flexor sheath of the fifth digit in bent position. MCP = metacarpophalangeal joint; PIP = proximal interphalangeal joint; DIP = distal interphalangeal joint; TFF = tip of the fifth finger; FP = flexor digitorum profundus; FS = flexor digitorum superficialis
Fig. 1b: Reflective points for high-speed video analysis

Similar damage may affect professional musicians, since frequent loads cause persistent dynamic stress to the hands of professional musicians (e.g., pianists). Especially frequent playing over long periods of time may cause overuse

syndromes. In a study of 179 musicians (Hochberg et al., 1983: N=49; Knishkowsky, et al., 1986: N=52; Dawson, 1988: N=78) damage caused by musculotendinous overuse was found in 62% of the subjects. Such damage is probably attributable, among other factors, to incorrect playing technique, as it can also be observed in beginners. Biomechanical studies of the loads placed on the fingers of pianists confirm this hypothesis (Wagner, 1985; Parlitz et al., 1998b; Harding, 1993, Leijnse, et al., 1992). Parlitz et al., 1998a, using a sensor-matrix-foil (F-Scan), studied the mean pulse per touch and the mean touch-duration occurring in various finger exercises played on the piano and detected great differences between beginners and advanced pianists.

METHODS: Dynamometric measurements of vertical forces, using a KISTLER force plate and three-dimensional cinematographic studies (high-speed camera system SPEEDCAM), were made of a skilled pianist playing a difficult composition by Franz Liszt (Après une Lecture du Dante); the high movement frequency (Triller) at which the piece was played placed great strain on the fingers. The fingertip of the fifth digit of the right hand and the distal interphalangeal joint, the proximal interphalangeal joint, the metacarpophangeal joint and the wrist were marked with reflective points for high-speed video analysis (Fig. 1b).

RESULTS: On the average, when striking the keys the fingers (of the two hands) must exert a medium force of 100-200 [N] (piano-forte) and 300-500 [N] (forte-fortissimo) (Fig.2).The total impulse p of the piece by Franz Liszt produced 10.415 [N*s].

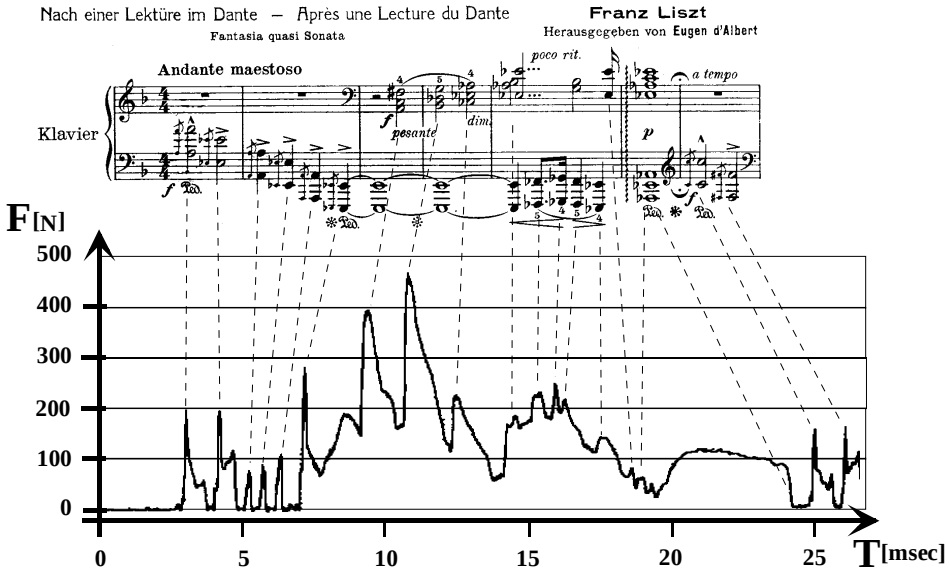


Fig. 2: Piano playing by a master pianist. Vertical forces F [N] produced by the fingers of the left and right hands while paying the first seven measures of a composition by Franz Liszt, measured on a piano mounted on a KISTLER measurement platform.

The maximum speeds of the fifth digit (distal phalanx) were 1.4 [m/sec] while playing "non legato accelerando" of a composition by Franz Liszt.

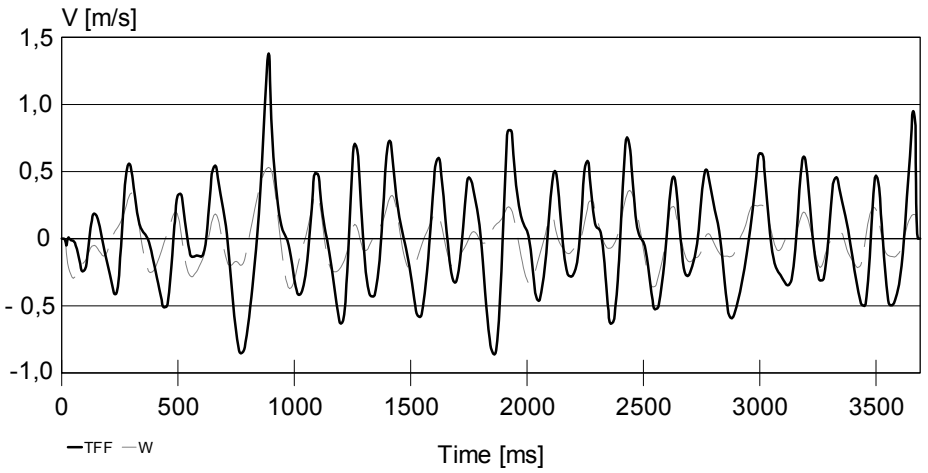


Fig. 3: Piano playing by a master pianist. Vertical velocity V [m/s] produced by the fifth digit of the right hand while playing "non legato accelerando" of a composition by Franz Liszt. Three-dimensional cinematographic studies (high-speed camera system SPEEDCAM). TFF = tip of the fifth finger; W = wrist.

CONCLUSIONS: The chosen method proved to be suitable for analyzing the technique of piano playing and determining loads placed on the fingers. This method may be used to recognize students' mistakes at an early point in time.

REFERENCES:

Burtscher, M., Jenny, E. (1987). Häufigste trainingsbedingte Beschwerden und Verletzungen bei Sportkletterern. *Praktische Sport-Traumatologie und Sportmedizin* **2**, 15-21.

Harding, D. C. et al. (1993). Finger Joint Force Minimization in Pianists Using Optimization Techniques. *J. of Biomechanics* **26**(12), 1403-1412.

Hochholzer, Th., Eisenhut, A. (1993). *Sportklettern. Verletzungen-Prophylaxe-Training* (pp. 35-42). München: Lochner-Verlag.

Leijnse, J. et al. (1992). Biomechanics of the Finger with Anatomical Restrictions – The Significance for the Exercising Hand of the Musician. *J. Biomechanics* **25**(11), 1253-1264.

Parlitz, D. et al. (1998a). Assessment of Dynamic Finger Forces in Pianists: Effects of Training and Expertise. Short Communication. Hannover: Institute for Music Physiology and Performing Arts Medicine, University of Music and Theatre.

Parlitz, D. et al. (1998b). Experimental Setup for a Combined Motion, Force and Sound Intensity Analysis of Professional Piano Technique. Brief Communication. Hannover: Institute for Music Physiology and Performing Arts Medicine, University of Music and Theater.

Wagner, Ch. (1985). Welche Anforderungen stellt das Instrumentalspiel an die menschliche Hand? *Handchirurgie* **19**, 23-32.