Delta Balance Standing Platform Evaluation
Executive Summary

The Delta Balance approached us to investigate scientifically and quantitatively the effect of the use of the Delta Balance standing platform.

An experiment was designed to study comparatively the effect of Delta Balance Platform (platform) use while standing on downward slope, horizontal surface, and upward slope. The study received ethics approval and 5 male and 5 female subjects were recruited. These subjects were required to stand on three surfaces for 5 minutes each.

Prior to the experimental session, after subjects had signed informed consent form, they were weighed, measured and their ages were recorded. The subjects attired in briefs or two piece swim suits. After suitable skin preparation active differential electrodes were placed on the bellies of tibialis anterior, gastromenemii (medial and lateral), vastus lateralis, vastus medialis, hamstrings, lumbar erector spinae and thoracic lumbar spinae all on the right side of the body. For reference activities the subjects were required to stand on heels, toes, and undergo full trunk flexion and subsequent extension. The EMG values for heel stand was used to normalized tibialis anterior (TA) and hamstrings (HM) toe stand for lateral gastrocnemius (LG) medial gastrocnemius (MG), vastus lateralis (VL) and vastus medialis (VM). Extension from flexed trunk posture was used to normalize lumbar erector spinae (l3) and thoracis erector spinae (T12).

The subjects were then asked to assume the three positions in a random order for five minutes in each position without moving their heads, torsos, arms or bending in any direction. A camera was placed in coronal plane at two meters to take profile picture at the start and at one minute intervals thereafter.

The EMG data was sampled at 1248 Hz for a period of five minutes after preamplifying the signals at source by a factor of 10. The raw signals were passed through a band pass filter with lower end cut off 20 Hz and the upper end cut off at 450 Hz. The signals were further amplified by a factor of 1,000 before recording on the computer hard disk. The amplifier was fully isolated and had a frequency response from DC to 5 kHz, and a common mode rejection ratio of 92 dB. Upon return to the laboratory the EMG signals were full wave rectified and linear envelope detected. The peak and average magnitudes were extracted in microvolts (uv) and normalized against the reference activity for the muscle in question. The raw data was used to carry out special analysis through Fast Fourier Transform to obtain Median frequency (MF), mean power frequency (MPF), total power (TP) and peak power (PP) fall muscles for each of the three activities were calculated.

Using the photographs of all subjects at every minute time interval the wrist, elbow, shoulder, hip, knee and elbow angles were measured. These angles along with the height, weight and gender of the subject was input into the University of Michigan biomechanical model. The analysis yielded lumbosacral compression and shear, L4/L5 compression and shear, and forces generated by the left and right erectors spinae at L3, T12, rectus abdominis (RA), internal oblique (IO), external oblique and latissimus dorsi (LD).

These data were analyzed statistically to provide descriptive statistics of means and standard deviations. Subsequently each of these variables was subjected to analysis of variance (ANOVA) to discern significant differences, if any.

Analysis revealed that the data throughout the five minute period of recording were not significantly different from each other. Hence all data for the five minute period were collapsed within the variable and mean values extracted. These represented the individual channel values for individuals. A global analysis of variance was carried out for all EMG variables and the two genders. The analysis revealed that there was no significant difference between males and females with respect to EMG variables expect the median and mean power frequencies. The data of two genders were pooled and subjected to ANOVA and multiple comparisons. The peak and average EMG for both raw and normalized EMG did not show significant difference between the three standing surfaces. However, when the EMG values were normalized against the down slope values and plotted the EMG magnitude (peak and average) the EMG output of all channels combined were lowest for the down slope standing. In frequency domain, the peak power and total power also did not show significant difference between the three standing surfaces. However, the median frequency and the mean power frequency showed significant differences between the three standing surfaces ($p<0.05$). The down slope had values lower than horizontal as well as upslope values. The significance of this finding is that the muscles are firing at a lower frequency to maintain the standing posture in down slope condition, hence lesser EMG demand for standing down slope.

Also, the mean total power and mean peak power for the downward slope were lower than the upslope as well as the horizontal values. A lack of significant difference in EMG magnitude data (peak and average EMG; and peak and total power) are thought likely due to overall very small magnitude of muscle activity. Furthermore, normalizing such low values against reference activities which involved significant effort may have further masked the difference. Therefore, additional higher resolution analyses are being undertaken.

The biomechanical analysis yielded some more decisive results. The lumbosacral compressions were found to be significantly different between males and females ($p<0.001$) as well as between the three experimental conditions tested ($p<0.01$). The downward slope had significantly lower lumbosacral compression than horizontal ($p<0.009$) and lower than the upslope as well. Standing on down slope generated significantly different forces in the erector spinae ($p<0.01$) from horizontal with a lower value mean value. The rectus abdominis, internal and external obliques also generated significantly different forces while standing on down slope as compared to both horizontal and upslope. In most cases the down slope standing generated lower forces. Therefore, it clearly demonstrates while standing down-slope one reduces the EMG demands and lumbosacral compression. The lumbosacral compression is the most important biomechanical variable related to causation of low back pain. A significant reduction in compressive load relieves the spine providing a scientific rationale for sustained use of this device to relieve chronic low back pain.

Dr. Shrawan Kumar, Ph.D, DSc.
Professor, Department of Physical Therapy;
Faculty of Rehabilitative Medicine;
Professor of Neuroscience, Faculty of Medicine;
Editor, International Journal of Industrial Ergonomics;
Consulting Editor, Ergonomics;
Advisor Editor, Spine;
Assistant Editor, Transactions of Rehabilitation Engineering