THE INFLUENCE OF WALKING SURFACES ON GROUND REACTION FORCE IN GATE ANALYSIS

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SUMMARY
This study evaluated the influence of sliding of surface on GRF for 15 normal subjects. They have walked on a surface by two force plates in two different states: dry and sliding. The data were analyzed in frequency range instead of time range by utilizing Fast Fourier Transformation (FFT) and in each frequency, the amplitude of tangential forces were investigated in voluntarily and reflexive motion ranges of frequencies of human movements. Figures of summation of all tangential forces resultant revealed that the amount of amplitude of GRF and slope of changes in dry surfaces is more than sliding surfaces in heel-strike and toe-off phases. Moreover, force vibration in dry surfaces is more considerable than sliding surfaces and it was more significant in heel-strike than toe-off. It was concluded that the dry surfaces are not completely safe and the impact that is imposed by ground in dry surface especially in heel-strike phase is high.

INTRODUCTION
A definite understanding of ground reaction forces (GRFs) is important for the creation of inverted pendulum models of gait [1], biomimetic walking robots [2], and prosthetic limbs for lower limb amputees [3]. Moreover, it is necessary to quantify impacts, understand Propulsion and braking, compute muscle forces, and calculate mechanical energy fluctuations [4]. Force plates have been known as reliable instruments in many studies in man. The goals of the present study were to investigate the effects of walking on different surfaces on GRF. For this purpose, a surface by two force plates was used in different condition, dry and sliding and 15 healthy subjects were tested by walking on it. Then the data were imported from Microsoft Excel into MATLAB and by frequency analysis, differences between two states were investigated.

METHODS
15 male students of University of social welfare and rehabilitation science by normal BMI (body mass index) 22-23 and natural pattern of walking were selected as subjects (Table 1). The natural pattern of walking that was considered in this research expressed as absence of any unusualness in walking that was clear by eyes. Every person had to walk by similar velocity in all parts of the tests which was free speed walking that is introduced for this age group (18-49) 98-138 step per minute. The shoes that were used for this test include an OXFORD shoes by one millimeter depth of groove. Each person must walk on a surface with two force plates (KISTLER 9286A) in different states: First, on a surface by dry force plates and then by sliding force plates. For sliding of force plates, definite amount of an industrial solution of suds was used. Outputs of test were classified in Microsoft Excel (2007) and then were imported into MATLAB (R2007b). In fact, results of force plates soft ware (BIOWARE) were in time range and they were changed to frequency range in MATLAB by utilizing of Fast Fourier Transformation (FFT). In frequency range, amplitude of tangential forces resultant was figured versus frequency in two different surfaces, dry and sliding, for each person. After that, summation of all amplitudes in the same frequency was figured in both states.

RESULTS
As expected, the amplitude of tangential forces in dry surface (Figure 1) is larger than sliding surface (Figure 2) (1.381e+005>1.209e+005) in stance phase. On the other hand, slope of decreasing of amplitude in walking on dry surface (Figure 1) is greater than sliding surface (Figure 2) (38220>33683). Of course, both figures are investigated in conscious and unconscious frequency of human movement. This means, all results of stance phase can be expectable in toe-off phase.

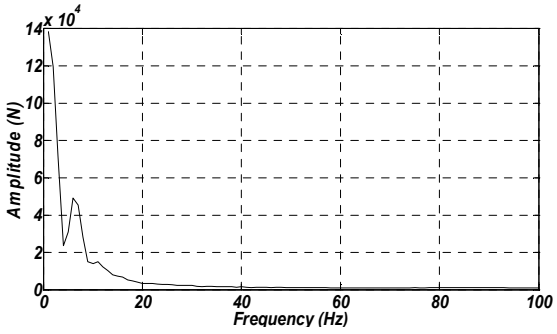

Figure 1: The amplitude of tangential forces' summation in frequency range of human movement in dry surface

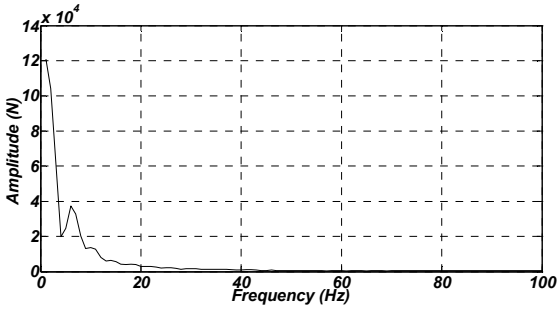

Figure 2: The amplitude of tangential forces' summation in frequency range of human movement in sliding surface

CONCLUSSION

In this paper, GRF was investigated as an important parameter in walking on different surfaces by utilizing FFT in frequency range. As expected, the amplitude of GRF in dry surface is brilliantly larger than sliding surface and this is observable in both heel-strike and toe-off phases. This means, in walking on dry surfaces, the impact that is imposed from ground is greater than sliding surfaces. On the other hand, the amount of force vibration in dry surfaces is more than sliding surfaces. This is logical because in sliding surface, body consciously or unconsciously tries to prevent from slipping. Therefore, body has minimum vibration in sliding surface. Furthermore, vibration in heel-strike phase is more than toe-off and it shows more instability in heel-strike phase. The slope of GRF's amplitude changes in dry surfaces is more than the other one. This suggests that during activity on dry surfaces, people should protect themselves due to they think because of dryness of surface, they are protected from any injuries. Of course, it doesn't mean the sliding surface is not important. This study also included only healthy subjects, and not enough older subjects to see the effect of age on GRF. Further work will assess investigation of GRF in other clinical population who are at risk of falls. Moreover, stability can be next factor for investigation that wasn't considered in this study and due to the amount of importance of stability in older people; it can be new goal for future studies.

REFERENCES

1. Donelan, J.M., Kram, R., Kuo, A.D., 2001. Mechanical and metabolic determinants of the preferred step width in human walking. Proceedings of Biological Science 268 (1480), 1985–1992.
2. Popovic, M.B., Goswami, A., Herr, H., 2005. Ground reference points in legged locomotion:Definitions, biological trajectories and control implications. The International Journal of Robotics Research 24 (12), 1013-1032.
3. Glaister, Brian C., Orendurff, Michael S., Schoen, Jason A., Klute, Glenn K., 2007. Rotating horizontal ground reaction forces to the body path of progression. Journal of Biomechanics 40 (2007) 3527–3532.
4. Gottschall, Jinger S., Kram, Rodger, 2004. Ground reaction forces during downhill and uphill running. Journal of Biomechanics 38 (2005) 445–452.

Table 1: Demographic information of subjects (n=15)

Variable	Amplitude	Maximum	Minimum	Average
Age (year)	15	20	35	24.50
Weight (kg)	23	63	86	71.13
Height (m)	14	170	184	177.59
BMI	5.21	20.19	25.40	22.53