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EVALUATION OF WALKING STABILITY BASED ON PLANTAR SKIN DEFORMATION MEASURED BY FEATURE POINTS

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SUMMARY

Plantar skin deformation has possibility which evaluate walking stability. A total of 30 (10 normal young males (22 ±2 years) and 20 normal elders (73±5 years)) human subjects were recruited in the research. We had human subjects walk on a walkway four times per one trial. Images of plantar skin of the right foot while stance phase were collected by a high speed camera under a transparent force plate. Feature points of plantar skin were calculated by using Harris corner image processing method. Changes of plantar skin contact area were calculated by using binarization images. As results, the changes of plantar skin contact area in the elder were significantly higher than the young group while the 2nd phase ($p<0.05$). Results of standard deviation of the changes of plantar skin contact area and the changes of plantar skin contact area without slipped area suggested that elder have more risk of falling than young while the 2nd phase and the 5th phase($p<0.05$). The changes amount of plantar skin contact area only slipped area in the elder group were significantly higher than the young group while the stance phase. This phenomenon suggested that elder tend to sliding feet while the stance phase. In conclusion, the plantar skin deformation measurement has a potential to estimate the walking stability and risk of falling.

INTRODUCTION

Walk is fundamental motion in human life. Everyday life isn't without walk. However, walk always involves risk of falling. Falling does not become the serious problem for the young people, however it becomes serious problem for infant and the elder people. In particular, the 10% - 40% elder have experienced falling for one year and 5% of falling occurred serious fracture accident [1]. It is serious problem for Japan leaving for the aging society however there are many unexplained parts, and elucidation is hurried about research of the walking. This study was focused on plantar skin deformation during a walk and it can be estimated that walking stability is analyzed by plantar skin deformation. Plantar skin deformation was measured by images of plantar skin while the stance phase during a walk. This research investigated plantar skin deformation and variability in elder and young. The changes of plantar skin contact area and the changes of plantar skin with and without slipped area were measured and compared while the stance phase.

METHODS

A total of 30 (10 healthy young males (22±2 years) and 20 healthy elder males (73±5 years)) human subjects were recruited in this research. The subjects were instructed to walk at their own pace on a walkway four times per one trial. Images of plantar skin of the right foot while the stance phase (Table1) was collected by a high speed camera (2048[pix] ×2048[pix], 150[fps], Point Grey Research, Inc. Figure 1). A walkway which used in this research made by acrylic boards and aluminium frames with reflection prevention materials. A transparent force plate (Tech Gihan, Inc.) was installed in the walkway (Figure 2). In this research, we calculated a plantar skin deformation by plantar images collected by the camera. The changes of plantar skin contact area were calculated by using binarization image and feature points of plantar skin were calculated by using Harris corner image processing method [2] (Figure3).

Figure 1: High speed camera

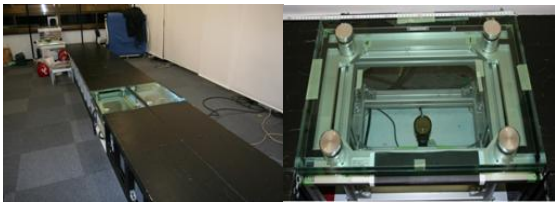
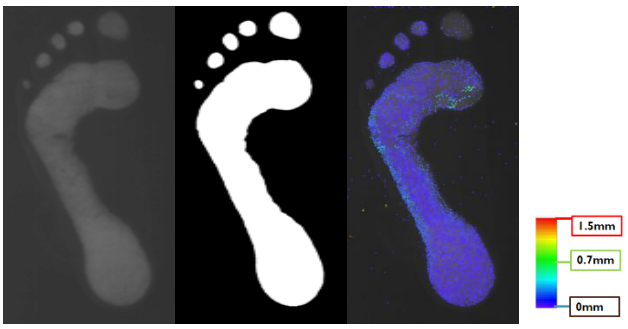


Figure 2: Walkway and transparent force plate

Table1: Eight phases in one cycle walking

Priod	Phase	word	Start point	Time(%)
Between stance phases	The 1st phase	Initial contact	The moment of leg touches the ground	0
	The 2nd phase	Rolling response	Initial grounding	0–19
	The 3rd phase	Mid stance	The moment of leg of the side opposite to separated from the ground	19–50
	The 4th phase	Terminal stance	The moment the heel of the leg separated from the floor	50–81
	The 5th phase	Front swing phase	Initial grounding of the opposite side	81–100



(a) Normal (b) binarization (c) Harris corner

Figure 3: Planter skins image processing
(Color is length of feature point move in (c) while 1 frame)

RESULTS AND DISCUSSION

Results of the experiments were shown in Figure 4 (The part with the shadow expresses significant difference ($p<0.05$)). When plantar skin contact area is calculated, maximum amount of the plantar skin contact area is normalized 1. Time is normalized 1 while the stance phase. Vertical axis is contact area and horizontal axis is time while stance phase. Maximum amount of the plantar skin contact area is normalized 1. Time is normalized 1 while the stance phase. The variability is calculated by standard deviation. Figure 4 (a) was expressed the plantar skin contact area. The changes of plantar skin contact area in elder group were significantly higher than young group ($p<0.05$). This phenomenon were obtained by having young people walk after icing their plantar skin for longtime [3]. Figure 4 (b) was expressed the standard deviation of the changes of plantar skin area. Figure 4 (c) was expressed the standard deviation the changes of the plantar skin contact area without slipped area. Results of Figure 4 (b) and Figure 4 (c) reported that elder have more risk of falling than young while the 2nd phase and the 5th phase. Figure 4 (d) expressed the changes of plantar skin with slipped area. The plantar skin with slipped area in elder group was significantly higher than young group while the stance phase ($p<0.05$). This result showed that the elder tend to sliding feet while the stance phase. The experimental results suggest that walking stability can be estimated based on the plantar skin deformation.

CONCLUSION

In this study, we obtained difference the plantar skin deformation between young group and elder group during a walk. The experimental results suggest that the plantar skin deformation measurement has a potential to estimate the walking stability and risk of falling.

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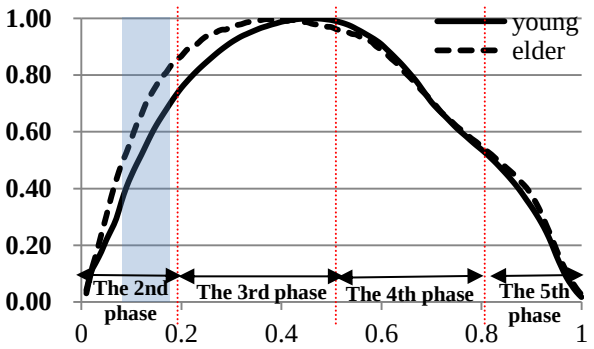
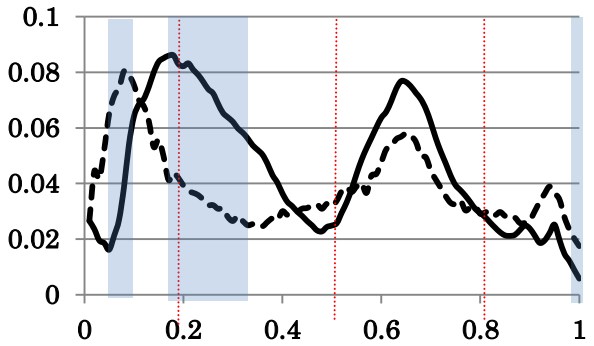
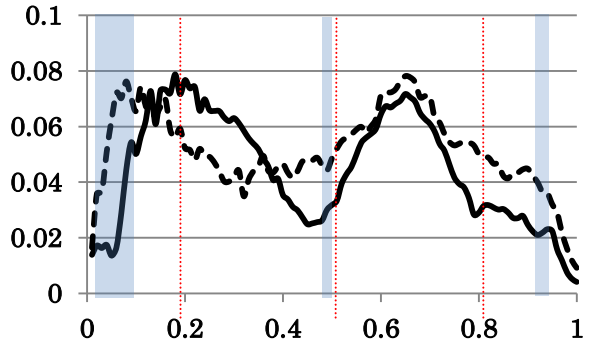


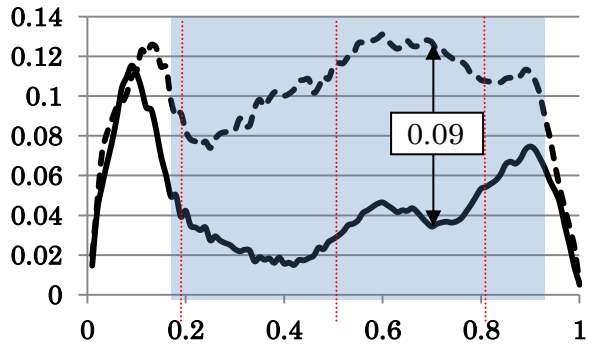
(a) The changes of plantar skin contact area



(b) The standard deviation of plantar skin contact area



(c) The standard deviation of plantar skin contact area without slipped area



(d) The changes of plantar skin only slipped area

Figure 4: Result of plantar skin deformation
(*The part with the shadow expresses significant different)