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Kinematic Properties of Young Active Woman Gait Initiation on Different Floor Coverings

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Abstract: *Introduction: A Gait initiation requires the movement from a stable double leg stance to the dynamic state ofwalking. Methode: The motion of participants was tracked (eight-camera motion analysis system,200Hz (Qualisys Sweden)) using reflective markers attached to the lower limbs. An initial static trial was used to establish the relationship among the markers and their respective segment markers. This allowed the tracking of dynamic movements using the markers. Findings: The least amounts of lateral deviation were found on artificial turf. The longest steps were found on granolith floor covering and the shortest ones were found on artificial turf. The widest steps were found on hard floor and the least amounts of width were found on PVC floor covering. The longest step times were found on artificial turf and the shortest step times were found on PVC floor covering. The longest swing phase times were found on artificial turf and the shortest swing phase times were found on PVC floor covering. The fastest steps were found on granolith floor covering and the slowest ones were found PVC floor covering. Conclusion: Kinematic characteristics of gait initiation on different floor covering are not the same, and facing new floor covering operate as a serious perturbation. It is suggested to plan for training and rehabilitation activity on the same surface as the real game court.*

Keywords: *Kinematic, Gait Initiation, Floor Coverings*

INTRODUCTION

Gait initiation requires the movement from a stable double leg stance to the dynamic state ofwalking. (Khorramymehr et al., 2008) This action requires the coordinated movement of both lower limbs. (Wentink et al., 2014) Several researches have been done on typical movement patterns for different ages of healthy adults and for those with disabilities. (Delval et al., 2017) Contacting with floor is a necessary factor for gait. As floor coverings have direct contact with foot sole, it may change the pattern of movement. (Kim et al., 2013) Human movements have complicated patterns that contain cooperation of some organs. People move on different kinds of floors. (Item-Glatthorn et al., 2016) Each kind of floor covering has different properties the same as stiffness, friction, power absorption capability, vertical deformation resistance to rolling loads and resistance to erosion. Performance improvement and damage reduction are so important matters in sport and kinesiology. It is expected, floors play significant role in these two main matters. On one hand several characteristics of floor covering and their effects on different movement have been considered in some researches. But there are few researches about comparing different kinds of floor coverings. On the other hand, gait initiation is one of the most fundamental and repetitive movements in competitive and team sport games. Floor covering is one of the main effective factors on gait movement pattern. Sports and rehabilitation activities usually are done in places with predetermined floor covering. Studies have shown that gait initiation on different floors leads to change kinetic and kinematic features of movement. The target of current study is comparing the effect of artificial turf, hard, granolith and PVC floor covering on gait initiation in 20 to 30-year-old active women.

Materials and Methods

Participants

In current research statistical societycontains 20 to 30-year age women who have done exercise three days a week during one year before test. 14 healthy active women between the ages of 20 and 30 years (age= 25± 2.6, hight=1605.71±22.26) without the history of acute and advanced neuromuscular, orthopedic, neurological, rheumatologic, psychological, diabetes, organ fractures, cardiovascular diseases and structural defects were selected randomly as a research sample. Institutional ethical approval was gained for the study and all participants gave written informed consent.

Motion Tracking

The motion of participants was tracked (eight-camera motion analysis system, 200Hz (Qualisys Sweden)) using reflective markers attached to the lower limbs. An initial static trial was used to establish the relationship among the markers and their respective segment markers. This allowed the tracking of dynamic movements using the markers.

Experimental Design and Measurements

Kinematic data were collected, at 200 Hz, by using of Qualisys eight cameras digital motion analyzer. Reflective markers were placed on bone landmarks on subjects' toe top and heel. All participants walked with bare feet and wore special tight cloth of motion analyzer. After calibration of the system subjects were asked to stand up with feet a comfortable self-selected width apart at the start determined place on walkway and begin to walk on their own decision along the walkway on their preferred speed. After one-minute rest they continued the process, until three acceptable trails have been established. In the next part of test, the floor covering were changed and subjects were asked to stand upon the special place and start to walk on their favorite speed on their own decision along the walkway. The same as previous part after one-minute rest they continued the process, until three acceptable trails have been established. This protocol took place for four floor covering.

Data Analysis

Marker data were tracked and filtered with 6 Hz Butterworth filter. Magnitude of first step width (normalized byhip width), first step length (normalized bylower limb), lateral deviation of forefoot, step speed, the time of an step and also each step phase across gait initiation on four surfaces for leading leg compared by using of repeated measure ANOVA. In common with previous reports14 the leg that progressed first is referred to as the leading leg and also that progressed second is referred to as the trailing leg. During the gait initiation the position of special markers were determined manually by examining graphical representation of specific marker displacement in conjunction with global movement of all markers attached to each subject. Movement characteristics for all participants were determined by examining movement of any of the markers. Initial step was determined from the toe off to the second toe off that defined by the minimum distance of top toe marker from floor on the X axis. Swing phase was determined from the first toe off to the first heel contact that defined by the minimum distance of heel and toe markers from floor on the X axis. Step width was determined as minimum strait distance between heel markers on Y axis in double support phase. Lateral deviation of forefoot was measured as lateral deviation of foot from X axis. Spatiotemporal outcomes were then calculated. Total step time was determined from the first toe off to the second toe off. Swing phase time determined from the first toe off to the first heel strike. From these measures the step speed (step length/step time) was calculated.

Results and Discussion

Findings

Kinematic characteristics of gait initiation (step length, step width, forefoot lateral deviation, total step time, swing phase time, step speed) on four different kinds of floor covering (artificial turf, PVC, granolith and hard floor) were collected. For reducing the effect of differences in size of participants on the results a normalization process was used. This involved multiplying all variables by appropriate normalisation quantities.

Normalised step length = step length x (1/LBH)

Normalised step width = step width x (1/HW)

Where LBH= lower body height, HW=hip width.
Step length=straight distance between first and second toe off
Step width=distance between two heel marker at double support phase
Total step time=time between first and second toe off

Results

Kinematic characteristics of gait initiation were quantified on four different floor covering,
results showed that participants could reasonably adopt. No significant differences were found in lateral deviation of forefoot in gait initiation on four different floor covering. The least amounts of lateral deviation were found on artificial turf. Significant differences were found in step length in gait initiation on different floor covering. The longest steps were found on granolith floor covering and the shortest ones were found on artificial turf. No significant differences between artificial turf and hard floor in step length outcomes were observed, but there were differences between artificial turf and granolith or PVC floor covering. And there were differences between hard floor and granolith or PVC floor covering. No significant differences between granolith and PVC floor covering in step length outcomes were observed. Significant differences were found in step width in gait initiation on different floor covering. The widest steps were found on hard floor and the least amounts of width were found on PVC floor covering. No significant differences between artificial turf and hard floor in step width outcomes were observed, but there were differences between artificial turf and granolith or PVC floor covering. And there were differences between hard floor and granolith or PVC floor covering. No significant differences between granolith and PVC floor covering in step width outcomes were observed. Significant differences were found in step time in gait initiation on different floor covering. The longest step times were found on artificial turf and the shortest step times were found on PVC floor covering. No significant differences between artificial turf and hard floor in step time outcomes were observed, but there were differences between artificial turf and granolith or PVC floor covering. And there were differences between hard floor and granolith or PVC floor covering. No significant differences between granolith and PVC floor covering in step time outcomes were observed. Significant differences were found in swing phase time in gait initiation on different floor covering. The longest swing phase times were found on artificial turf and the shortest swing phase times were found on PVC floor covering. No significant differences between artificial turf and hard floor in swing phase time outcomes were observed, but there were differences between artificial turf and granolith or PVC floor covering. And there were differences between hard floor and granolith or PVC floor covering. No significant differences between granolith and PVC floor covering in swing phase time outcomes were observed. Significant differences were found in step velocity in gait initiation on different floor covering. The fastest steps were found on granolith floor covering and the slowest ones were found PVC floor covering. No significant differences between artificial turf and hard floor in velocity outcomes were observed, but there were differences between PVC floor covering and artificial turf or granolith or hard floor covering. Significant differences between velocity of gait initiation on granolith floor covering and artificial turf or hard or PVC floor covering were observed.

Discussion

There are several researches about walking on different kinds of surfaces with different characteristics. Some of these characteristics are slippery (friction), tightness and coefficient of reaction. In Gait initiation subjects confront new strange floor covering. Gait adaptation should be employed to continue walking safely on new surface. Mizusava et al. had studied the processes of anticipatory postural adjustment and step movement of gait initiation. The result of this study indicated that processes of anticipatory postural adjustment and step movement of gait initiation are produced as a dual process. So in the current research we can consider gait initiation and facing new floor as a dual process. (Mizusawa et al., 2017) Stanfield et al. examined the kinematic of gait initiation whit different speed in healthy adults. Result showed gait initiation spatiotemporal and kinematic characteristics were quantified across the maximum range of speeds achievable, providing comprehensive characterization of changes with speed. Significant changes with speed, suggesting different strategies are employed to modify speed at low and high speeds. These changes with speed illustrate the importance of taking speed into account when comparing outcomes between healthy adults. (Stansfield et al., 2018) As it was said in current research participant walked on their own selected speed, so the results are not affected by speed. Shulman et al. investigated age-related alterations in reactive stepping following unexpected mediolateral perturbations during gait initiation. The result showed the participant older than 65 altered their stepping patterns by reducing their BOS (more narrow step width compared to younger group), and required more than the two steps used by younger group to complete the goal-directed task. (Shulman et al., 2018) In the current study we considered different kinds of floor covering as a perturbation but the participants were young and active. In current research kinematic variables of gait initiation changed on different kinds of floor covering, but in the study by Shulman et al. kinematic variables of gait initiation did not change by unexpected mediolateral perturbations. (Shulman et al., 2018) It may be concluded that floor coverings are more effective perturbation on gait initiation. Gait adaptation on different surfaces was investigated by Chang et al., by exposing the participants to walkways with different degrees of slipperiness produced by five floor covering types under three surface conditions. In this experiment, the results for trial 1 for most of the cases were significantly different from those of the rest of the trials for most of the kinematics and kinetics variables, especially for the conditions in the low and high friction categories. It means eventually, they would reach strategies that they could utilize to walk safely on those surfaces regardless of their friction degree. It is the main reason that we investigated the kinematic variables of gait initiation on different kinds of floor covering. The results imply that gaits for the walkways in the medium and high friction categories were almost the same and the participants may have gained more confidence as they continued walking on the walkway with medium friction degree. The results indicate that most variables in the low friction category were different from those in the medium and high friction categories, while no difference was found between medium and high friction categories. In the current research we found most of variables the same as step length, step width, total step time and swing phase time of the gait initiation almost the same on the hard surface and artificial turf, and also almost the same on granolith and PVC floor covering. It may be because of different friction of surfaces. As reported by Chang et al., the required COF could be as high as 0.41 for safely walking, this amount of COF is considered as high friction category. So it is expected some gait adjustments would be needed by the participants in order to safely walk on the surfaces in the low and medium friction category. (Chang et al., 2014) The current results showed that people can more safely walk on granolith and PVC surfaces rather than the hard surface and artificial turf. Chang et al. investigated participants walking on a 7 m slippery surface, while the force plate areas in the middle of the walkway. (Chang et al., 2008) The majority of their response measurements were different from those in the experiment of Chang et al. In this experiment kinematic of gait was investigated but in the current study gait initiation was investigated, so direct comparisons of the results from two experiments could be difficult formost of the variables.

Since the results of Chang et. al. about surfaces with different friction showed that trial one of four or five walking trail was significantly different from other trials for most of the kinematic variables, especially for the low and high friction conditions, they concluded that participant can make adaptation whit high and medium friction surfaces, but more adjustments were needed for low friction surfaces. Kinematic parameters on high and medium friction surfaces were very similar, but more adjustments were needed for low friction surfaces. They said since participants in this experiment were aware of the floor conditions, the results could have important safety implications that user awareness alone might be insufficient for safe floor designs. (Chang et al., 2017) It matches whit the result of current study. Although the participant could see the floor covering and they were aware of the changes of the surface the kinematic of gait initiation was significantly different on different floor. As Menant et al. said subjects walked faster on the regular surface than on the irregular and wet surfaces. Subjects required more time and distance to stop, and exhibited a smaller BOS length on the wet surface than on the control surface. These results are in commen with the result of current study about hard floor covering, participant had the lowest step width in gait initiation on that. In current study participants walked bare on different floor covering. It may be comparable with whit studies about different kinds of foot wear. (Menant et al., 2009) Franklin et al. did a systematic review of the kinematic, kinetic and muscle activity differences during walking barefoot and walking with common footwear. The results showed spatial-temporal differences including, reduced step/stride length and increased cadence, when participants walked barefoot. It is similar to walking barefoot on the hard floor. In current research in gait initiation on hard floor step length is shorter than step length of gait initiation on granolith and PVC floor covering that is match with the results of investigation had been done by Franklin et al., but in gait initiation on hard floor step length is longer than step length of gait initiation on artificial turf that is not match with the result of Franklin et al. (Franklin et al., 2015). Najafi et al. studied the impact of foot orthoses on gait initiation. The result showed that kinematic of gait initiation was changed during barefoot condition compared to both shod alone and shod with foot orthoses conditions and foot orthoses improve dynamic postural control during walking too. In this research stride velocity in barefoot gait initiation was less than two other conditions. In current study the velocity of gait initiation on hard floor is less than granolith, so it may say granolith floor covering can act the same as both shod alone and shod with foot orthoses conditions. (Najafi et al., 2010)

Conclusion:

Summing up kinematic characteristics of gait initiation on different floor covering are not the same, and facing new floor covering operate as a serious perturbation. It is suggested to plan for training and rehabilitation activity on the same surface as the real game court.

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