Effects of variations in sand surface type on muscle activation patterns at landing in beach volleyball

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Introduction
Although some studies report a higher injury rate for beach volleyball played on sand surfaces compared to volleyball played on indoor surfaces (e.g. Aagaard et al., 1997), other studies have reported the opposite trend (Briner et al., 1999). It is possible that between-study differences in volleyball injury incidence were partially attributed to variations in the properties of the sand surfaces upon which the beach volleyball games were played. However, no study was located examining the effect of variations in beach volleyball playing surfaces on landing technique and, in turn, lower limb injury potential. Therefore, the aim of this study was to examine the effects of variations in sand surface properties on lower limb muscle activation patterns displayed during landing in beach volleyball.

Methods
Twelve male beach volleyball players (age: 26 ± 4 years, height: 184 ± 7 cm, mass: 80 ± 8 kg) performed five modified spike jump movements from a drop jump bench (0.52 m) onto both dry non-compacted sand (DRY) and wet compacted sand (WET). The subjects were asked to land with the dominant limb first, as it is typical in beach volleyball landings. All trials were performed immediately following three series of weighted standing vertical jumps (SVJ) and one final set of unweighted SVJ to simulate the lower limb muscle fatigue that players may experience in beach volleyball. Each series consisted of 30 jumps with 3 seconds pause between each trial and 1 minute rest between each series. During each trial ground reaction force data and surface EMG data for rectus femoris (RF), vastus medialis (VM), vastus lateralis (VL), biceps femoris (BF), semitendinosus (ST) and medial gastrocnemius (MG) of the landing limb were recorded (1000 Hz). Muscles onset and offset times were determined using a threshold detector (10% of peak activation) in combination with visual inspection of the raw signal to confirm accuracy. Paired t-tests then were used to detect significant differences in the variables as a function of surface type (p < 0.05, indicated by * in Fig. 1,2).

Results and Discussion
Although the peak vertical ground reaction force generated at landing increased significantly from 3.1 BW on the DRY to 3.9 BW on the WET surface, there was no significant difference in the time at which the peak force occurred (DRY: 47 ms; WET: 44 ms). Figure 1 and Figure 2 show the onset and offset times of the investigated muscles with respect to foot contact. MG onset and offset times were significantly earlier compared to the hamstring muscle activation times for both the DRY (On: 39-50 ms earlier; Off: 62-115 ms earlier) and WET (On: 48-72 ms; Off: 56-111 ms) surfaces. When landing on the WET surface, activity in the knee extensors was off later relative to the knee flexors (92-203 ms vs. 248-287 ms). Furthermore, on the WET surface, MG was activated significantly earlier compared to landing on the DRY surface (131 ms vs. 112 ms). All knee extensors on the WET surface showed a later offset compared to when landing on the DRY surface, although this difference was only significant for RF (258 ms vs. 211 ms).
Although the peak vertical ground reaction force increased by nearly 30% on the WET compared to the DRY surface, VM and ST showed only small differences in preactivation time with no clear differences in VL offset detected.

Fig. 3 shows the time of activation for all muscles defined by the time interval between onset and offset. In general, the knee extensors were activated longer compared to the knee flexors, especially when landing on the WET surface. Irrespective of the sand surface properties, preparation to land began with activation of the MG, with deceleration of the players’ momentum generated during landing being controlled predominantly by the knee extensors. When landing on the more rigid sand surfaces, the delay in offset of the knee extensors may increase patellar tendon loading as the players attempt to decelerate following foot-sand contact. Earlier activation of the knee flexors on the more rigid surfaces may act as a mechanism to stabilise the knee joint against the more abrupt decelerative forces in attempt to minimise potential for lower limb injuries, particularly when fatigued.
Fig. 3: Activation period for all muscles on DRY (blue) and WET (red) surface

References