Does fatigue induced by repetitive weighted standing vertical jumps affect muscle activation patterns during landing in beach volleyball?

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Introduction
Since the introduction of beach volleyball to the 1996 Olympic Games in Atlanta, the sport has increased in both popularity and in participation rates. Beach volleyball differs from its more traditional indoor counterpart in several ways, including the surface it is played on and the number of players who take the court (Aagaard et al., 1997). For example, while there are six players per team in the indoor version of the sport, there are only two players per team in beach volleyball. Consequently, beach volleyball players tend to be exposed to a great number of repetitions of the movements performed in a typical game compared to indoor players and, in turn, may be at a greater risk of fatigue related injuries. The high incidence of overuse injuries incurred in beach volleyball, such as patellar tendonitis, have been attributed to factors including the repetitive jumping movements typical of the game (Aagaard et al., 1997; Briner & Ely, 1999) and player fatigue. However, no study was located examining the effect of fatigue on the landing technique of beach volleyball players, particularly neuromuscular strategies used by players when fatigued. Therefore, the purpose of this study was to examine if fatigue induced by repetitive jumping affected lower limb muscle activity patterns displayed during landing on sand.

Methods
Twelve skilled male beach volleyball players (mean (SD) age = 26 ± 4 yr; height 184 ± 7 cm; mass 80 ± 8 kg) performed five modified spike jump movements (SJM) from a bench (0.52 m) to land dominant limb first onto a wet compacted sand surface. The subjects then performed three maximal standing vertical jumps, hands remaining on hips, while a marker, which was placed on the greater trochanter of the dominant landing, was automatically tracked using an OptoTrak 3020 motion analysis system to determine the subject’s maximum vertical jump height. Once the maximum vertical jump height was determined, a 30% reduction in the standing vertical jump height was calculated.

In order to simulate the lower limb muscle fatigue that players may experience in beach volleyball, subjects were fatigued by performing a series of standing vertical jumps. Subjects performed approximately four sets of 30 standing vertical jumps (SVJ, 30 s rest interval between sets) while wearing a weight belt (~ 10% BW). Jump sets continued until a 30% decrease in SVJ height was attained after which a final set of 30 SVJ were performed without a weight belt. Immediately following the fatigue task, each subject repeated five post-fatigue SJM onto the sand. Three orthogonal components of the ground reaction forces generated during each trial were collected using a Kistler force platform (Type 9281B) in conjunction with a Kistler multichannel charge amplifier (Type 9865A). The platform, flush with the floor, was covered with wet compacted sand, which was contained within a bottomless wooden frame to ensure a constant contact sand depth (102 cm x 102 cm x 19 cm) to replicate beach volleyball conditions. During each SJM trial, surface EMG data were also recorded (1000 Hz) for rectus femoris (RF), vastus medialis (VM), vastus lateralis (VL), biceps femoris (BF), semitendinosus (ST), and the medial head of gastrocnemius (MG) using a Noraxon Telemyo EMG system. After processing, a threshold detector (10% of peak activation) was then applied to linear envelopes representing each muscle burst, in conjunction with visual inspection, to determine temporal characteristics of the muscle bursts at landing relative to foot-ground contact (FGC) and the peak vertical ground reaction force (VGRF). Paired t-tests were then applied to the data to determine if there were any significant differences between the variables pre-fatigue compared to post-fatigue (p < 0.05)
Results & Discussion
When fatigued subjects activated MG significantly later, relative to both FGC (112 ± 60 ms) and the peak VGRF (159 ± 58 ms) compared to when not fatigued (FCG = 121 ± 49 ms; peak VGRF = 171 ± 51 ms). Furthermore, in the fatigued condition peak RF muscle activity occurred significantly later after FGC (-82 ± 21 ms) compared to the non-fatigued condition (-66 ± 23 ms). There was also a significant delay in the time of peak RF activity relative to timing of the peak VGRF when fatigued (-35 ± 22 ms) compared to non-fatigued (-17 ± 29 ms).

Irrespective of the fatigue condition, the players generated the same vertical ground reaction forces at landing. However, despite generating the same ground reaction forces, the fatigue induced by repetitive jumping affected the muscle synchrony used by players when absorbing these high impact forces. For example, delayed MG onset when fatigued reduced the time available for players to plantar flex their feet in preparation for a forefoot landing before impacting the sand, possibly reducing the ankle joint motion available to dissipate the high impact forces. The delay in peak RF muscle activity caused by fatigue suggests that players may also be less efficient in using their knee extensors to control deceleration of their body mass during landing. This may lead to players developing higher patellar tendon forces when fatigued, thereby increasing the risk of developing patellar tendonitis, although further research is recommended to investigate this association. Additionally, since the drop jump bench height was held constant throughout all SJM trials, further investigation is recommended to investigate the effects of fatigue when the jump height is not held constant.

References