Timing of Muscle Synergies and Knee and Hip moments During the Stand-to-Sit

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ABSTRACT

The timing of the hip and knee moments regulates precise control of the center of mass (CoM) during a stand-to-sit (StandTS). Alteration in hip and knee moment timing may increase the risk of falling. Muscle synergy patterns, as a diagnostic tool, may indicate the change in the timing of hip and knee moments. However, the relationship between the timing of synergy levels and hip and knee moments has yet to be assessed. **PURPOSE**: To evaluate the relationship between the time-to-peak of StandTS synergies with the time-to-peak of knee extension, hip flexion and abduction moments. **METHODS**: Ten healthy male adults (31.5 ± 5.1 yrs, 80.4 ± 6.6 kg) volunteered for this study and performed three StandTS trials. Kinematic, Kinetics, and muscle electromyographic (EMG) activity were assessed using 12 Vicon cameras, 2 Bertec force plates, and Delsys Trigno EMG, respectively. Because the hip and knee joint muscles are the prime movers of the StandTS, surface EMG was recorded bilaterally from the vastus lateralis, vastus medialis, semitendinosus, biceps femoris, and gluteus maximus. EMG data were filtered (10-500 Hz) and linear enveloped (15 Hz) using a zero-lag Butterworth filter. Non-negative matrix factorization was applied with 1-10 ranks to extract muscle synergies. The variance accounted for (VAF) was used to evaluate the preciseness of fit. The highest VAF for the lowest number of synergies was selected. The time-to-peak of the muscle synergies were calculated and normalized to StandTS duration. The knee and hip moments were calculated using a generic OpenSim musculoskeletal model with 12 segments, 23 degrees of freedom, and 92 tendon actuators, scaled to the participants' anthropometric data. Pearson's correlation was used to assess the relationship between the time-to-peak of muscle synergies and the time-to-peak of hip and knee moments. **RESULTS**: The VAF for StandTS was highest for 5 synergies (98.33 ± 0.1). The time-to-peak of the 1st synergy level was positively correlated with the time-to-peak of the hip flexion moments (right leg: $r = 0.817$, $P = 0.04$ and left leg: $r = 0.943$, $P = 0.004$). The time-to-peak of the 2nd synergy was significantly correlated with the time-to-peak of the hip flexion moment (right leg: $r = 0.89$, $P = 0.01$ and left leg: 0.93, $P = 0.007$). The time-to-peak of the 3rd synergy was positively correlated with the peak of hip flexion moment on the left leg ($r = 0.93$, $P = 0.006$) but not on the right leg ($P = 0.054$). The time-to-peak of the fourth synergy was positively correlated with the time-to-peak of the knee extension moment in the right leg ($r = 0.87$, $P = 0.02$) and TP of hip flexion moment (right leg: $r = 0.83$, $P = 0.04$ and left leg: $r = 0.86$, $P = 0.03$). Finally, the TP of the 5th synergy was positively correlated with the time-to-peak of knee extension moment for the left ($r = 0.863$, $P = 0.02$) and right legs ($r = 0.938$, $P = 0.005$). **CONCLUSION**: Our VAF results showed that StandTS have five synergy levels. The timing of the 1st and 2nd synergies correlate with the timing of the hip flexion moment. Whereas the fourth and fifth synergies were correlated with the timing of the knee extension moments. Thus, muscle synergy timing can be used as a diagnostic tool for assessing abnormalities that alter the timing of the knee and hip moments during transitional tasks.