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Rotational and Linear Accelerations of an Anthropometric Test Dummy Head from Taekwondo Kicks among Amateur Practitioners

Authors : Gabriel P. Fife, Saeyong Lee, David M O'Sullivan

Abstract : Introduction: Although investigations into injury characteristics are represented well in the literature, few have investigated the biomechanical characteristics associated with head impacts in Taekwondo. Therefore, the purpose of this study was to identify the kinematic characteristics of head impacts due to taekwondo kicks among non-elite practitioners. Participants: Male participants (n= 11, 175 + 5.3 cm, 71 + 8.3 kg) with 7.5 + 3.6 years of taekwondo training volunteered for this study. Methods: Participants were asked to perform five repetitions of each technique (i.e., turning kick, spinning hook kick, spinning back kick, front axe kick, and clench axe kick) aimed at the Hybrid III head with their dominant kicking leg. All participants wore a protective foot pad (thickness = 12 mm) that is commonly used in competition and training. To simulate head impact in taekwondo, the target consisted of a Hybrid III 50th Percentile Crash Test Dummy (Hybrid III) head (mass = 5.1 kg) and neck (fitted with taekwondo headgear) secured to an aluminum support frame and positioned to each athlete's standing height. The Hybrid III head form was instrumented with a 500 g tri-axial accelerometer (PCB Piezotronics) mounted to the head center of gravity to obtain resultant linear accelerations (RLA). Rotational accelerations were collected using three angular rate sensors mounted orthogonally to each other (Diversified Technical Systems ARS-12 K Angular Rate Sensor). The accelerometers were interfaced via a 3-channel, battery-powered integrated circuit piezoelectric sensor signal conditioner (PCB Piezotronics) and connected to a desktop computer for analysis. Acceleration data were captured using LABVIEW Signal Express and processed in accordance with SAE J211-1 channel frequency class 1000. Head injury criteria values (HIC) were calculated using the VSRSoftware. A one-way analysis of variance was used to determine differences between kicks, while the Tukey HSD test was employed for pairwise comparisons. The level of significance was set to an effect size of 0.20. All statistical analyses were done using R 3.1.0. Results: A statistically significant difference was observed in RLA ($p = 0.00075$); however, these differences were not clinically meaningful ($\eta^2 = 0.04$, 95% CI: -0.94 to 1.03). No differences were identified with ROTA ($p = 0.734$, $\eta^2 = 0.0004$, 95% CI: -0.98 to 0.98). A statistically significant difference ($p < 0.001$) between kicks in HIC was observed, with a medium effect ($\eta 2 = 0.08$, 95% CI: -0.98 to 1.07). However, the confidence interval of this difference indicates uncertainty. Tukey HSD test identified differences ($p < 0.001$) between kicking techniques in RLA and HIC. Conclusion: This study observed head impact levels that were comparable to previous studies of similar objectives and methodology. These data are important as impact measures from this study may be more representative of impact levels experienced by non-elite competitors. Although the clench axe kick elicited a lower RLA, the ROTA of this technique was higher than levels from other techniques (although not large differences in reference to effect sizes). As the axe kick has been reported to cause severe head injury, future studies may consider further study of this kick important.

Keywords : Taekwondo, head injury, biomechanics, kicking
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