RELATIONSHIP OF BODY MASS AND BILATERAL RUNNING GAIT PARAMETERS IN ELITE AMERICAN FOOTBALL PLAYERS

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Sprinting is integral to American football and is thought to be influenced by the same gait parameters as track runners; however, the heavier mass of American football players may influence performance. The purpose of this study was to investigate the relationship between mass, contact time (T_C), aerial time (T_A), swing time (T_S), and stance-averaged vertical ground reaction forces (vGRF) for both limbs. Subjects ran on an instrumented treadmill for 5 sec at 6.5 m/s. T_c, T_A, T_S and stance-averaged vGRF were compared between limbs and examined for association with mass. All parameters were symmetrical between limbs, p>.05. Mass (103.0±12.2 kg) was moderately associated with T_c (0.17±.02 sec) on the left, r=0.666, p=0.013, but not the right (r=0.551, p=.051). The high mass of American football players may affect variables associated with speed.

KEY WORDS: football biomechanics, kinetics, speed mechanics

INTRODUCTION: American football players are required to run at high velocities in situations that directly influence the outcome of a game. For example, during a pass play, a player from the opposing team will run to tackle the receiver or intercept the ball. These bouts are typically only 15-20 yds (13.7-18.3 m) with receivers running longer distances and lineman running shorter distances. While players will rarely achieve their top speed during a game, the ability to accelerate in the run is paramount. Further, players seeking to be drafted by the National Football League (NFL) showcase their running abilities in a 40 yard dash, 20 and 60 yard shuttle, and 3 cone drill. The top performers in these running events are usually the running backs, wide receivers and defensive backs (http://www.nfl.com/combine/tracker); these are the lighter players. However, heavier players such as the linebackers, tight ends and fullbacks must also demonstrate speed. Speed in sprinters is influenced by ground contact time (T_C), flight or aerial time (T_A), vertical ground reaction force (vGRF) magnitude, and limb acceleration during the swing phase (Weyand, 2017). Shorter T_C have been associated with faster running times and greater force application with T_C ranging from 0.100 to 0.250 sec, depending upon speed (Paavolainen, Nummela, Rusko, & Häkkinen,1999; Weyand, Sternlight, Bellizzi, & Wright, 2010). Mokha, Peacock and Bommarito (2018) found longer T_C in heavier Big Skill (e.g., linebackers, tight ends) vs. lighter Skill (e.g., wide receivers, running backs) American football players during a sub-maximal controlled run, suggesting that mass may be related to gait parameters. Little is known how or if larger heavy runners such as American football players apply forces differently during speed running. Findings would be useful to coaches and athletes in speed development. Therefore, the purpose of this study was to determine if mass was associated with selected temporal and kinetic gait parameters during a sub-maximal controlling running bout. Specifically, we examined the relationships between mass, contact time, aerial time, swing time, and stance-averaged vertical ground reaction forces of both limbs in a group of elite American football players. We also compared the aforementioned gait parameters between left and right limb contacts. Results of this study may yield the influence of body mass on speed running kinetics in American football players.

METHODS: Thirteen adult males (age, 21.9±0.8 yrs; height, 1.86±0.11 m; mass, 103.0±12.2 kg) undergoing specialized training at an off-campus performance center for the NFL combine volunteered for this study. All participants had just completed their collegiate football season and were active players training 5-6x per week. The study was approved by the University's Institutional Review Board, and subjects provided written informed consent. All data were collected over two days with each athlete reporting to one testing session. This study was part of a larger study monitoring pre-post changes in vertical and drop jumping, sprinting mechanics, and body composition over the duration of the 7-week training camp. All participants underwent a standardized 25 minute warm-up in the laboratory instructed by the same coach from the performance center where the athletes were training for the NFL combine. It consisted of dynamic stretching, muscle readiness and reactivity exercises designed to progressively warm-up the athlete for jumping and running activities. Participants showed to the laboratory two at a time, and therefore, were able to immediately begin testing post warm-up. The sub-maximal running trial took place on an instrumented split belt treadmill (Bertec, Columbus, OH, USA) with participants running on one side only. Participants began the trial holding onto the handrails adjacent to and/or in front to the treadmill and fixed at waist height walking at 1 m/s, then the treadmill was increased 1 m/s in one sec increments until 6.5 m/s was reached. Participants were instructed to release their grip when they were comfortable, and data were collected at 1000Hz for a period of 5 seconds. This time was selected to mimic most 40yd dash durations at the NFL combine. Subjects then transferred their weight to the non-moving belt, then the treadmill belt was decelerated to a stop. See Fig. 1. Only one trial was collected. All trials were post-processed with a low pass Butterworth filter with a cut-off frequency of 40Hz. Data presented represent the average of three consecutive steps for each leg. right leg steps. The variables of interest were defined as follows: (a) *stance-averaged ground reaction force (vGRF)* was the average vertical ground reaction force (BW) during the step, (b) *ground contact time* (T_C) was a measure of continuous foot-ground contact time (sec) with the treadmill when the vGRF exceeded 40N, (c) *aerial time* (T_A) was a measure of time (sec) that elapsed between the end of one foot-ground contact and the next, and (d) *swing time* (T_S) was a measure of time (sec) that elapsed between the end of one foot-ground contact and the beginning of that same foot's next contact.

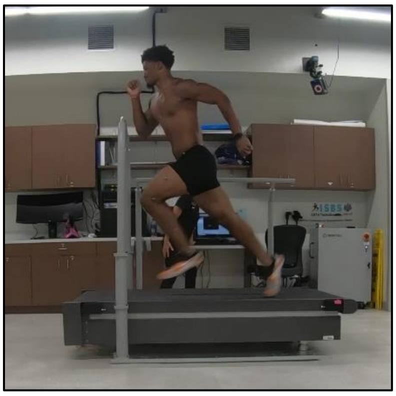

Figure 1. Subject completing 5s run at 6.5 m/s on the instrumented treadmill.

Data were transferred to a customized Excel file to extract the dependent variables. Statistics Package for Social Sciences (ver. 25; IBM Corporation, New York, NY, USA) was used for statistical analyses. Pearson's correlation coefficients were calculated to determine associations between mass, T_c, T_A, T_S, and stance-averaged vGRF for all subjects. Paired Samples T-tests were used to determine differences in the dependent variables between right and left limb contacts. Statistical significance for all tests was determined as $p<.05$. Correlation strength was determined according to Hinkle, Wiersma, and Jurs (2003) and is as follows: 0.90 to 1.00 (-0.90 to -1.00) as very high, 0.70 to 0.89 (-0.70 to -0.89) as high, 0.50 to 0.69 (-0.50 to -0.69) as moderate, 0.30 to 0.49 (-0.30 to -0.49) as low, and 0.00 to 0.29 (0.00 to −0.29) as negligible.

RESULTS: Table 1 presents the means of the gait parameters for each limb. There were no significant differences in gait parameters between right and left limb contacts, $p>.05$. Mass was only significantly correlated with one gait parameter studied. There was a significant, positive moderate correlation between mass and T_c on the left, $r=0.666$, $p=0.013$, but not the right, $r=0.551$, $p=0.051$. See figures 2 and 3.

Table 1. Mean Gait Parameters for Right and Left Limb Contacts (N=13).

Variable	Right Limb Contact	Left Limb Contact	*p* value
T_C (sec)	0.17 ± 0.02	0.17 ± 0.02	0.851
T_A (sec)	0.12 ± 0.01	0.12 ± 0.03	0.824
T_S (sec)	0.41 ± 0.05	0.40 ± 0.03	0.518
Ave vGRF (BW)	1.59 + 0.17	1.52 + 0.15	0.372

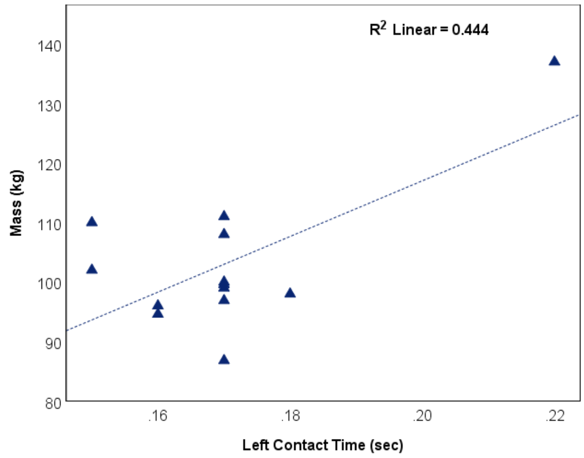

Figure 2. Relationship between mass and left limb contact.

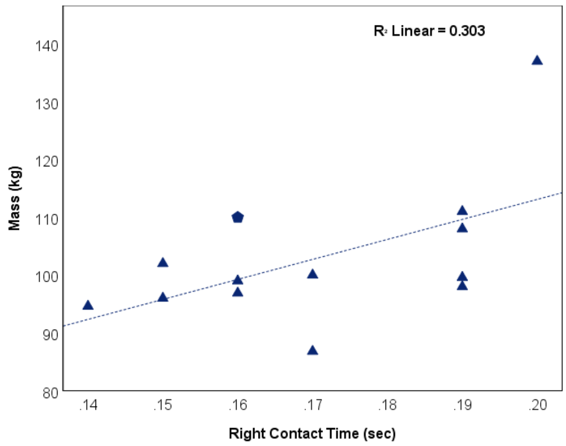

Figure 3. Relationship between mass and right limb contact.

DISCUSSION AND CONCLUSIONS: The purpose of this study was to investigate the influence of mass on factors that determine sprint speed in a group of elite American football players. We sought to determine the relationship between mass, T_c, T_A, T_S and stance-averaged vGRF as well as identify differences in the dependent variables between right and left limb contacts. Results showed that there was a moderate, positive association between body mass and left limb T_C during the treadmill run. Time spent during ground-contact increased as player mass increased. T_c is a relevant performance variable in sprinting, as it is the only period when large amounts of muscle force are generated and transmitted to the support surface. A shorter T_C has been associated with faster running time and greater force application during shorter T_C (Paavolainen, Nummela, Rusko, & Hakkinen,1999; Weyand, Sternlight, Bellizzi, & Wright, 2010). T_C in competitive running is typically 0.100 to 0.250 sec, depending upon speed. Results of this study show T_C of our participants within normal, expected limits. Since the running speed was controlled in this study (6.5 m/s), the longer contact times seen from the participants with larger mass are interesting. Studying a similar participant sample, Horn and colleagues (2018) reported overall body mass and lean muscle mass to be negatively correlated with reactive strength during a drop jump. Heavier American football players had lower reactive strength. Mass may be a limiting factor in activities such as jumping and running despite the large force assumed to be produced. Interestingly in this study, although not statistically significant, there were negative correlation coefficients for the associations between mass and left (r=-0.298) and right (-0.402) stance-averaged vGRF. This may suggest heavier players are not producing forces as expected. Coaches and players seeking speed training for NFL combine or similar performance demands will benefit from understanding which factors are related. Heavier players may not be able to achieve shorter T_C without reducing their mass. However, given the different position requirements of typically heavier players, this strategy may compromise other areas of performance. Results of this study lead us to conclude that foot-ground contact time was influenced by body mass.

CONCLUSION: This study resulted in sport-specific findings during a sub-maximal controlled running trial by elite American football players. Mass was positively associated with foot-ground contact time during left limb contact. While the correlation coefficient for the right side was positive for mass and foot-ground contact time, it was not statistically significant. There was symmetry in foot-ground contact, aerial, and swing times as well as stance-averaged ground reaction forces between right and left sides. In summary, heavier players appear to have longer ground-contact times. Further research will continue to analyze running in elite American football players in a controlled setting.

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