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Analysis of three different sprints starts in US football.

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SUMMARY

Increase players' safety during football is an important issue and US authorities recently request measures to improve players' safety during the game. Biomechanics of head and trunk during three different sprints starts were studied to evaluate if one position can be safer than the other ones.

INTRODUCTION

Doing sport safely, especially contact sport is an important issue. In the United-States approximately 300,000 concussions due to sport are listed every year [1]. Football is the most affected sport (47% of the concussions are met in football). Overall concussion rate is 2.5 per 10,000 athletes and 6.4/10,000 in football [1]. Guidelines for evaluation and management of concussion due to sport have been established [2]. The National Football League (NFL) is requesting to increase players' safety [3] because concussion can lead to severe neurological damages [4]. One of the issues could be the so-called 'starting position in 3 points' because this position would be responsible of most of the accidents. However no previous study has evaluated the influence of initial player position on the risk of collision. The objective of this study was to perform a biomechanical analysis of three different sprint start positions to determine the safest position in term of neck injury and concussion , and if differences could be found between players and non-players to evaluate the effect of learning process.

METHODS

Twenty five young and healthy males participated in this study (height=181±9cm, weight= 80±16kg, age= 24±2). Twelve of them where football players (height= 181±8cm, weight= 89±15kg, age= 24±3, mean experience in US football= 4±2 years). A control group of thirteen non-player subjects (all students at the local Faculty of Motor Sciences, and therefore relatively well-trained) has been selected to match the average height with the player group's. (height= 180±9cm, weight= 73±13kg, age= 23±3). For the weight there was a difference of 16 (7) kg between the two groups. This study was approved by the Ethical Committee of the Erasme Hospital and written informed consent was obtained from all subjects prior to participation in this study.

Results were obtained from a stereophotogrammetric system (Vicon, 8 MXT40s cameras, Vicon Nexus software, frequency: 100Hz). Subjects were equipped with 20 reflective markers (4 on the head, 4 on the thorax, 4 on the pelvis, 3 on each upper limb and 1 on each thigh) directly set on the subjects' skin. Subjects were in underwear and barefoot to performe the study trials.

After marker placement, subjects were asked to performe three sprint starts in three different initial positions encountered in football (Figure 1). The correct motion to be performed was first demonstrated by an experienced football player. Subjects were then invited to perform the motion once (without recording). After this trial, 3 successive datasets were recorded for each of the 3 start modalities leading to a total of 9 trials for each subject.

From the reflective markers' trajectories, several parameters were computed to compare the initial position and the overall motions adopted by the subjects. The Height of the head was expressed in percentage of the maximal height of the head compared to the floor. Two angles were further computed: the inclination of the trunk with the floor, and the angle between the head and the trunk. To have more precise information's about the position of the head we computed these two angles into a "Verticality" angle. This angle was obtained by Eq. 1.

$$\text{Verticality}\,(°) = (180° - \text{Inclination of the Trunk}(°)) + (180° - \text{Head Angle}(°)) \qquad \text{(Eq. 1)}$$

A verticality angle close to 0° indicated a head close to being vertical.

Verticality of the head is an important point to reach a maximal visual field, and thus to minimize the risk of injury due to collision. A ratio between the height of the head and the verticality was computed as "Visual Field" (Eq. 2)

$$\text{Visual Field} = \text{Height of the head}\,(\%) / \text{Verticality}\,(°) \qquad \text{(Eq. 2)}$$

This Visual Field must be as high as possible.

For each trial, the start and the end times (when head's height is reaching maximal value) of the motion where manually detected. For each subject, the 3 trials of the same start position were averaged. The 'redress time' (defined as the time from start until the head reaches maximal value) was obtained by subtracting the start time from the end time.

The head speed (vertical) was computed from the head height and the redress time. The body speed was computed 1 second after the start of the motion.

RESULTS AND DISCUSSION

Table 1 summarizes the results for the three different positions and the two groups. Figure 1 summarizes starting position for the three sprint starts. Adopting a 4-point start position leads to a lowering of the visual field (by 0.07) compared to 3-points start position. The 2-points starting position is much higher and the trunk is more vertical, the visual field is thus increased. Except for the initial head height during 4 points starts (5%) no difference was found between football player and non-player.

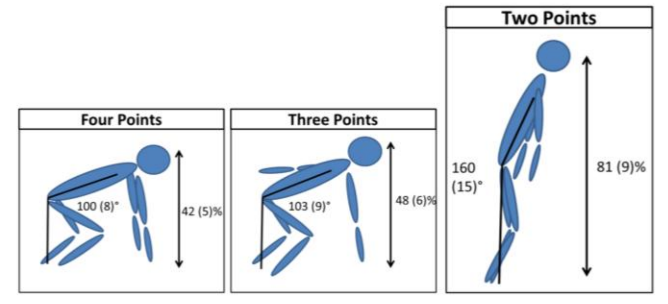

Figure 1: Initial position for the three conditions

Figure 2 presents the evolution of the head height during motions. No difference was found for the redress time thus the head speed (in the vertical direction) is higher for the 4-point start position compared to the 3-points (0.10 m/s) and 2-point (0.60 m/s). For the body speed (horizontal displacement) no difference was found between the 3- and 4-points but speed was lower for the 2-point start (0.30 m/s). No difference was found between players and non-players.

CONCLUSIONS

Two main results can be underlined. The first one is that from a biomechanical point of view, the 4-point start would be more dangerous than the 3point start because the initial position of the head is lower and redress speed is higher.The safest position leading to a more optimal visual field is the 2-points start, but body speed is lower that could lead to a reduction of the player performance. The second main result of this study seems to show that the effect of training does not influence the starting performance. Thus training does not seem to lead to safest motion. This lack of difference could be due to the sport background of the control population. In conclusion, security can be increased with equipment and modification of the rules. This study is a first step into a more complete comprehension of risk/benefice balance of these three different positions. Balance needs to be found between safety of the player and the player performance.

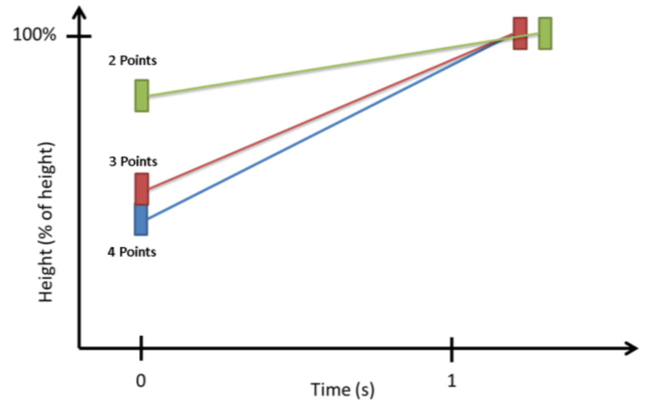

Figure 2: Evolution of head's height during early phase of the sprint.

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Table 1: Mean (sd) values obtain for the three different sprint start, initial position and values during de motion.
*** indicate difference between football player and non-player (at 0.05 level).**
$^{\alpha}$ indicate difference between 4 and 3 points (at 0.05 level).
$^{\beta}$ indicate difference between 4 and 2 points (at 0.05 level).
$^{\Omega}$ indicate difference between 3 and 2 points (at 0.05 level)

		4 Points			3 Points			2 Points		
		Football player	Non player	All	Football player	Non player	All	Football player	Non player	All
Initial Position	Head height (%)	**39 (4)**	**44 (4)***	42 (5)	46 (5)	50 (7)	***48 (6)*** $^{\alpha}$	81 (8)	80 (10)	***81 (9)*** $^{\Omega\beta}$
	Inclination of the Trunk (°)	103 (11)	98 (4)	100 (8)	**106 (5)**	**100 (10)***	103 (9)	160 (13)	159 (16)	***160 (15)*** $^{\Omega\beta}$
	Head Angle (°)	135 (26)	137 (15)	136 (20)	140 (16)	144 (14)	***142 (15)*** $^{\alpha}$	145 (6)	143 (11)	144 (9)
	Verticality (°)	122 (23)	125 (13)	123 (18)	114 (17)	117 (17)	***115 (17)*** $^{\alpha}$	55 (19)	58 (24)	***55 (21)*** $^{\Omega\beta}$
	Visual Field	0.34 (0.05)	0.36 (0.04)	0.35 (0.04)	0.41 (0.07)	0.43 (0.07)	***0.42 (0.07)*** $^{\alpha}$	1.58 (0.40)	1.54 (0.46)	***1.56 (0.43)*** $^{\Omega\beta}$
Motion	Redress Time (s)	1.25 (0.2)	1.18 (0.2)	1.22 (0.18)	1.25 (0.2)	1.18 (0.1)	1.22 (0.18)	1.30 (0.2)	1.33 (0.2)	1.32 (0.22)
	Head Speed (m/s)	0.90 (0.13)	0.85 (0.08)	0.87 (0.11)	0.80 (0.15)	0.77 (0.11)	***0.78 (0.13)*** $^{\alpha}$	0.27 (0.14)	0.27 (0.15)	***0.27 (0.14)*** $^{\Omega\beta}$
	Body Speed (m/s)	2.70 (0.37)	2.63 (0.69)	2.67 (0.55)	2.59 (0.59)	2.63 (0.58)	2.61 (0.56)	2.21 (0.47)	2.44 (0.56)	***2.33 (0.52)*** $^{\Omega\beta}$