Human Movement Science 62 (2018) 105–115

Contents lists available at ScienceDirect

Human Movement Science

journal homepage: www.elsevier.com/locate/humov

The effects of sport specific training of rugby players on avoidance behaviours during a head-on collision course with an approaching person

Lana M. Pfaff, Michael E. Cinelli*

Department of Kinesiology and Phy. Ed., Wilfrid Laurier University, Waterloo, ON, Canada

ARTICLE INFO

Keywords:
Human locomotion
Motor behaviour
Obstacle avoidance
Perception-action integration
Time-to-contact

ABSTRACT

Individuals use visual information to plan and adapt movements to dynamically changing environments. This information is used to accurately determine when and where they may come in contact with an object. More specifically, individuals may determine the time prior to contacting an object, known as time-to-contact (TTC). Sport provides a scenario where athletes compete in dynamically changing environments and must interact with opposing players. The effects of sport-specific training on obstacle avoidance is highly controversial and research suggests the quantifiable differences in behaviours compared to non-athletes is highly context specific. The current study aimed to examine if sport-specific training has an impact on the avoidance behaviours of rugby players during a head-on collision course with an approaching person. Female rugby players (N = 10, $\bar{x}$ = 20 ± 0.94 years) and non-athletes (N = 10, $\bar{x}$ = 21.9 ± 1.6 years) were instructed to walk along a 10 m path towards a goal located along the midline. A female confederate initially positioned along the midline 180° from the participant walked towards the participant to one of four predetermined final positions: 1) along the midline in the participants' starting position; 2) stopped along the midline 2.5 m from her starting position; 3) to the left of the participants' starting position; and 4) to the right of the participants' starting position. Results revealed when the path of the confederate was uncertain, individuals used a consistent TTC to determine when to change their path. The rugby players in the current study were found to avoid significantly later (i.e. smaller TTC) than non-athletes. However, following a change in path, sport-specific training did not impact the avoidance behaviours of the groups, but rather the environment was the regulating factor. When the path of the confederate was uncertain, individuals did not use a single avoidance strategy, instead considered the fit between their individual characteristics (i.e., action capabilities) and components of the environment (i.e. path of the confederate and task constraints). Athletes who are specifically trained to pass through spaces and avoid obstacles (i.e., rugby backs) may consider their action capabilities in conjunction with their visual information to determine time of avoidance.

1. Introduction

The avoidance of another human is critical and may present more dire consequences when unsuccessful in a sport setting. Athletes are suggested to have specifically trained visual strategies in which they may extract important information from the environment

* Corresponding author.
E-mail address: mcinelli@wlu.ca (M.E. Cinelli).

https://doi.org/10.1016/j.humov.2018.09.010
Received 11 June 2018; Received in revised form 19 September 2018; Accepted 25 September 2018

(Fajen, Riley, & Turvey, 2008). Using this information, athletes have increased ability to use body- and action-scaled perceptual judgement to move efficiently throughout the world. During locomotion, the visual system provides instantaneous information from a distance. Individuals are able to use visual information in an anticipatory manner to guide their behaviours and make on-line adjustments (Higuchi, 2013). The temporal component of visual information is used to determine when to initiate movements. More specifically, individuals are able to directly perceive the time prior to colliding with an object (time to contact, TTC) (Lee, 1974; Lee, Lishman, & Thomson, 1982; Savelsbergh, Whiting, Burden, & Bartlett, 1992). After determining when to initiate a movement, what strategies and how an individual moves is dependent on a number of features. More precisely, these strategies are based on an individual's possibilities for action (affordances), which are dependent on characteristics of the observer and physical properties of their environment (Gibson, 1979).

During obstacle avoidance, individuals maintain a protective zone which allows for time to perceive, evaluate, and react to potential hazards in their environment (Templer, 1992). Previous research suggests individuals maintain an elliptical shaped protective zone during obstacle avoidance (Cinelli & Patla, 2007; Gérin-Lajoie, Richards, & McFadyen, 2005; Hackney, Van Ruymbeke, Bryden, & Cinelli, 2014). Gérin-Lajoie and colleagues (2005) found individuals maintain 2.11 m anteriorly and 0.48 medial-laterally when avoiding a stationary obstacle. This protective zone decreased by 22% when the obstacle was moving along a predictable path to allow individuals to gather more information prior to initiating an avoidance (Gérin-Lajoie et al., 2005).

Previous literature has found controversial results regarding the avoidance behaviours of athletes. The inconsistencies suggest athletes may perform differently depending on environment constraints and form of locomotion. Higuchi and colleagues (2011) found that while running, American football players elicited smaller magnitudes and later onset shoulder rotations when passing through a gap compared to non-contact athletes. However, Hackney, Zakoor and Cinelli (2015) did not find a difference in the avoidance behaviours or path selections of American football running backs and non-athletes while running during a similar aperture-crossing task. The discrepancies between the two studies are most likely related to the paradigm, such that Hackney et al. (2015) allowed individuals to pass through or around the aperture, whereas Higuchi and colleagues (2011) confined their participants to passing through the aperture. This suggests that during a non-confined obstacle avoidance task, specifically trained athletes do not display differences in their avoidance behaviours while running. Whereas, Gérin-Lajoie and colleagues (2007) found that while fast walking, athletes completed a non-confined multi-obstacle avoidance task faster and used more efficient paths than non-athletes. However, few field sports involve athletes avoiding stationary inanimate obstacles; therefore, it is critical to understand how behaviours differ when avoiding another person under sport specific environments. Pfaff and Cinelli (2017) found that regardless of the type of locomotion, rugby players chose paths furthest from the human obstacle. Additionally, while moving with a ball (i.e., walking or running), medial-lateral (ML) spatial requirements were smaller and less variable than while walking without the ball (Pfaff & Cinelli, 2017). This finding suggests the sport-specific behaviours may not be dependent on the form of locomotion, but rather moving in a sport-specific context (i.e., moving with a ball).

The purpose of the current study was to identify the effects of sport-specific training on avoidance strategies during a head-on (180°) collision course with an approaching person. Previous research has suggested individuals regulate TTC while avoiding obstacles. Cinelli and Patla (2007) examined whether individuals use a consistent TTC while avoiding a head-on collision. The path of the obstacle was highly predictable and therefore individuals changed their paths at the same location from the start position, regardless of TTC. Since the current study used a confederate who walked along one of four different paths, which were randomized and unpredictable to the participants, it was hypothesized that individuals would maintain a consistent TTC to regulate their time of avoidance and change their path at a consistent temporal distance from the approaching person. Additionally, rugby players avoided significantly later during a sport specific context (i.e., running with the ball) than while walking or walking with a ball (Pfaff & Cinelli, 2017). Since the current study presents a sport specific scenario with an approaching human obstacle, it was hypothesized that rugby players would maintain a smaller TTC than non-athletes.

As previously suggested, affordances (i.e. opportunities for action) are dependent on the fit between the environment and characteristics of the individual (including body size and action capabilities) (Fajen, 2013; Gibson, 1979). Based on the affordance-based model of obstacle avoidance, individuals consider their body dimensions and action capabilities relative to the environment during obstacle avoidance (Fajen, 2013). Individuals can use affordances to guide either the time of an avoidance or the manner in which they avoid the obstacle. Cinelli and Patla (2007) observed that individuals controlled the magnitude of lateral deviation during obstacle avoidance (i.e., ML spatial requirement) across different approach velocities of the approaching obstacle. Whereas Cinelli and Patla (2007) used a predetermined path of the approaching obstacle and altered the velocity of approach, the present study examined the effects of an unknown path on avoidance behaviour. Similarly, it was hypothesized that ML spatial requirement would not be affected by characteristics of the obstacle (i.e., path of the confederate), but rather would be impacted by an individual's action capabilities (sport-specific training). Since Higuchi and colleagues (2011) found that football players elicited smaller shoulder rotation magnitudes during aperture crossing, it was hypothesized that rugby players would maintain a significantly smaller ML spatial requirement than non-athletes at the time of crossing.

The findings from Cinelli and Patla (2007) suggest that individuals modulate the rate at which they avoid an obstacle. More specifically, as the approach speed of the obstacle increased, so did the ML rate of avoidance (Cinelli & Patla, 2007). This suggests that as the risk of a collision increases (i.e. increased approach velocity), individuals will avoid faster. The current study instructed participants to avoid the approaching confederate. More specifically, the confederate walked along a prescribed path and if the participant did not initiate the avoidance, they would collide. Therefore, of the four confederate paths, the greatest potential for a collision existed when the confederate walked along the midline. As such, it was hypothesized that individuals would avoid the approaching confederate at a faster rate when she approached along the midline. Additionally, since it is expected that the rugby players will avoid later than their non-athlete counterparts, it is expected that they will avoid the confederate at a faster rate than the