

THE EFFECT OF GENDER AND PERCEIVED THREAT ON THE REACTION AND MOVEMENT TIMES OF YOUNG ADULTS PERFORMING A SIMULATED SPORT-PROTECTIVE RESPONSE

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INTRODUCTION

The upper extremities are used to protect the head and body from impact with an object or the ground. Previous work has shown age, gender, and perceived threat significantly affected movement times in seated subjects blocking an approaching object at head level [1]. Reaction time and movement time both play an important role in determining the safety of athletes on the playing field. For example, baseball and softball pitchers have at most 420 ms to respond to a ball batted directly at them, when failure to block it could lead to catastrophic injury and/or death [2]. This study tested the null hypothesis that neither gender nor perceived threat will affect the reaction time or movement times of young adults when blocking a foam ball projectile aimed directly at their face.

METHODS

Nineteen healthy young adults (8 male, 11 female; mean age 27.5 years; mean height 173.3 cm; mean weight 71.8 kg) participated in this study. Subjects were equipped with a protective mask and chest protector. An air cannon located at head height directly in front of the subject fired a bright yellow foam tennis ball directly toward the subject's head at 21 m/s. The distance between the end of the cannon and the subject was incrementally decreased (61 cm increments) to increase task difficulty. The subjects started with both hands on their hips and moved both hands up to protect their face after the ball was fired. The subjects indicated when they were prepared for the cannon to fire. The air cannon fired the projectile after a random time delay of up to three seconds. Subjects underwent at least 4 trials at a distance of 8.25 m to become comfortable with the experiment ('low threat'). Subjects were then moved progressively closer to the cannon until they reached a distance (4–6 m) where they failed to block at least 4 of the 8 trials ('high threat').

Data collection began when the projectile cleared a light gate at the muzzle of the air cannon. An Optotrak Certus (Northern Digital, Waterloo, Ontario, Canada) motion capture system was used to measure forearm kinematics at 1 kHz. Optoelectronic markers were placed over the ulnar styloid on the left wrist and across the horizontal plane through the sternoclavicular joints. The initiation of protective motion was defined as the instant where the acceleration of the forearm exceeded $3 \times SD$ of the mean acceleration at rest. The completion of the protective motion was defined as the instant the forearm broke the sternoclavicular reference plane. Myoelectric measurements were recorded at 2 kHz from the infraspinatus, middle deltoid, brachioradialis, and extensor capri ulnaris muscles. The onset of myoelectric activity was defined by identifying the points at which the myoelectric activity was 5% and 10% above baseline noise levels and thence, via linearly extrapolation, back to baseline noise level.

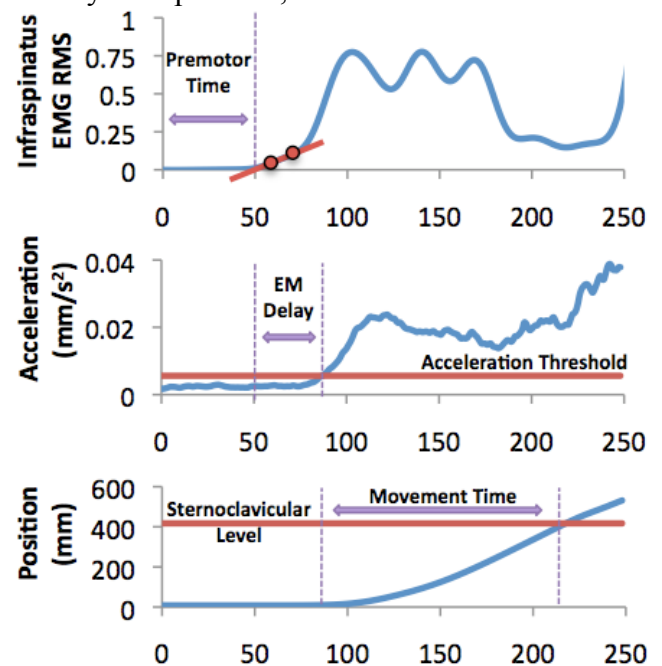


Figure 1. Illustration of premotor time, EM delay, and movement time for a typical trial.

Premotor time was the interval between the projectile breaking the light gate plane until the first onset of myoelectric activity. Electromechanical (EM) delay was the interval from the first onset of myoelectric activity to the initial acceleration of the forearm. Reaction time was the sum of premotor time and EM delay. Movement time was the interval from the initial acceleration of the forearm until the ulnar marker broke the horizontal sternoclavicular plane. These measurements are illustrated in Figure 1. A two-way ANOVA was used to test the effects of perceived threat and gender on reaction and movement time and $P < 0.05$ was considered significant.

RESULTS AND DISCUSSION

Reaction time and movement time both differed significantly with gender ($p < 0.001$) and perceived threat ($p < 0.001$), but the interactions of perceived threat X gender did not reach significance for either measurement. Males had a 27% reduction in mean reaction time and a 19% reduction in mean movement time with increasing perceived threat levels, while females showed a 21% reduction in mean reaction time and a 14% reduction in mean movement time with increasing perceived threat levels (Figure 2). The blocking accuracy for all subjects was 94% at the ‘low threat’ level and 39% for the ‘high threat’ level.

The use of an air cannon for measuring reaction time simulates an athletic response time similar to blocking a baseball or softball coming directly at the head. These results show that subjects blocking

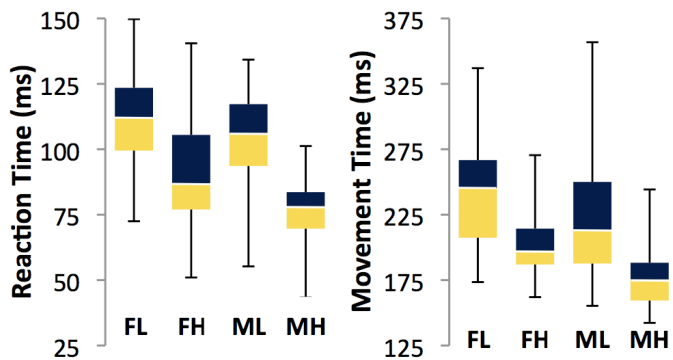


Figure 2. Box plots for reaction time and movement time. Boxes represent quartiles and the tails represent the max and min values. (F=Female, M=Male, L=Low Threat, and H=High Threat)

a ball aimed directly at their face from relatively close (‘high threat’ level) have a mean response time below 420 ms (Men: 250 ms, Women: 288 ms).

The fact that females had slower reaction times than males may be due to physiological or motivational factors. Gender differences have indeed been noted in simple and choice reaction times in healthy adults [3], and females sprinters had significantly slower simple reaction times than did male sprinters at the Beijing Olympics [4]. However, gender differences in speed-accuracy tradeoff could still be responsible: in aiming tasks, for example, males emphasize speed; females emphasize accuracy [5].

A limitation of our study is that an auditory cue preceded the visual stimulus by a small amount. A microphone mounted on one subject’s helmet showed that sound was detected 5–17 ms before the ball reached the end of the cannon, depending on the distance the subject was from the cannon. However, since the sound was detected at a consistent time for each distance, it does not invalidate the overall study findings.

CONCLUSIONS

Both gender and perceived threat significantly affect reaction and movement time in young adults protecting their face from an approaching ball.

REFERENCES

1. DeGoede KM, et al. *J Gerontol* **56A**, M584-M588, 2001.
2. McDowell M and Ciocco MV. *Br J Sports Med* **39**, 223-225, 2005.
3. Der G and Deary IJ. *Psychol Aging* **21**, 62-73, 2006.
4. Lipps DB et al. Submitted *Am Soc Biomech*, 2009.
5. Rohr LE. *J Mot Behav* **38**, 431-437, 2006.

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