HEAD MOVEMENT IN OVERARM THROWING FOR CHILDREN WITH VARYING LEVELS OF MOTOR PROFICIENCY

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The purpose of this study was to investigate head motion of children of varying levels of motor ability performing an overarm throw towards a forward facing target. Ten ten-year-old children were analysed using three-dimensional veideographic techniques. Angular motion of the head about its three axes was determined with respect to the external reference frame and with respect to the trunk. It was found that all subjects stabilised their heads during the performance of the throw. The angular velocity of the head immediately prior to release small despite large trunk angular velocity.

KEY WORDS: head movement, overarm throw, motor proficiency

INTRODUCTION: Overarm throwing has its origins when children first start to squash, shake drop and throw objects (Marques-Bruna & Grimshaw, 1997). In its adult form, it is characterised as gross fundamental motor skill that relies on the generation of torques about joints to produce linear motion of a projectile (Kreighbaum & Barthels, 1996). Sports skills like baseball pitching, throwing a javelin, and tennis serving are advanced versions of overarm throwing (Walkley, Holland, Treloar & Probyn-Smith, 1993).

The importance of the head in the control of fundamental motor skills is basically twofold. Since the head is an extremity of the body with substantial mass, it might be hypothesised that the head would move in some 'kinetic chain' fashion during the performance of an overarm throw. This would be due to the torques about the other joints of the body.

The head can also be categorised as a source of sensory information as it contains “the two most important perceptual systems for detecting self-motion with respect to space”, namely, the visual and vestibular (Pozzo, Berthoz & Lefort, 1990, p. 97). These two systems provide feedback during the execution of a skill and feedback after execution to allow modification of a particular 'motor program'. These systems also help maintain balance during the whole performance of the movement.

Overarm throwing performance is greatly affected by perceptual skills, motor skills and inter-segmental mechanics (Marques-Bruna & Grimshaw, 1997, p. 1267). Most results indicate that continuous visual information during the performance of the skill is paramount to success (Elliot & Leonard, 1986, pp. 518-519).

Head stabilisation in space during natural human movements is imperative for maintaining visual stability (Keshner & Chen, 1996, p324). To allow for optimum visual sensory input, the head must be controlled or stabilised (Pozzo, Berthoz & Lefort, 1990). Pulaski, Zee and Robinson, (1983) reported a marked decrease in the usefulness of visual information when head angular velocities were above 350 degrees/s.

In motor proficiency terms, qualitative studies have reported that children with lower motor proficiencies tended not to focus on the target when performing an overarm throw. Also, since the overarm throw is a dynamic activity, movement by certain segments of the body must influence other segments. Vereijken, Whiting and Newell (1992) reported a 'release of degrees of freedom' in joint angles, as a performer became more proficient at a skill.

The key research questions asked in this study were:

Is there evidence that the head is stabilised to perform an overarm throw to a target?

1. When, and for how long does this stabilisation occur?
2. Is there a relationship between the extent and timing of head stabilisation and motor proficiency in this study?

METHOD: Ten subjects (8 female, 2 male) aged 10yrs participated in the study. Each

subject performed several warm-up throws towards a wall. A motor proficiency score was obtained for each subject's throwing ability using the Test for Gross Motor Development (TGMD) (Ulrich, 1985). These scores were based on the mature form of the overarm throw.
Reflective marking balls were secured to several sites on the subjects' bodies. In addition, the subjects wore a 'skull cap' with three reflective markers that defined a plane parallel to the 'Frankfort Plane'. The subject then performed three overarm throws towards an A3 size target place at the subject's eye level four meters in front of them. Six 8mm-video cameras placed around the subject recorded these throws. The video data were automatically digitised using the APAS software. The co-ordinate data were then smoothed at five Hz and mathematically manipulated in a customised Fortran program to produce component and resultant angular velocity profiles of the head and trunk. The mathematical manipulations used were based on Areblad, Nigg, Ekstrand, Olssen and Ekstrom's (1990) study of foot motion during running. Component velocities were measured in the anterior-posterior, tilt and twist directions (Figure 2). These velocities were measured with respect to the internal as well as the external reference frame.
All angular velocity profiles were normalised from start and end frames to one hundred percentiles using a quintic spline function. The start frame was defined as the frame in which a 10 cm y-axis displacement difference in left and right shoulder markers appeared. The end frame was selected as the frame in which a horizontal velocity of 0.2 m/s of the ball with respect to the wrist was attained.
Statistical Analysis. Maximum values were calculated for each subject over all component and resultant angular velocity profiles of the head with respect to the external and trunk reference frames. Mean head angular velocities were also plotted against mean trunk angular velocities. A 95% confidence interval envelope graph was plotted. Significant differences between the instantaneous angular velocities of the trunk and head were indicated by a lack of overlap of those envelopes. Lastly, all the subjects' motor proficiency scores was correlated against maximum resultant and component angular velocities of the head with respect to the external axis and the head with respect to the trunk. A Pearson's correlation was used.

RESULTS: Only one subject had resultant angular velocities above the 350 degree/s threshold (See Table 1). Trunk angular velocities were much larger than the readings for the head. Significant differences between the trunk and head resultant angular velocities occurred after 78% of the throwing time (See Figure 1).

Table 1 Motor Proficiency Scores and Maximum and Mean Resultant Velocities for Each Subject

Subject	Motor Proficiency (%)	Head wrt External Max (deg/s)	Head wrt External Mean (deg/s)	Head wrt Trunk Max (deg/s)	Head wrt Trunk Mean (deg/s)
1	67	233	121	841	199
2	83	48	31	455	131
3	92	167	54	604	183
4	100	312	118	472	131
5	33	96	35	573	155
6	75	329	136	573	198
7	58	181	80	533	203
8	92	112	32	748	134
9	50	156	50	291	122
10	100	435	134	1768	270

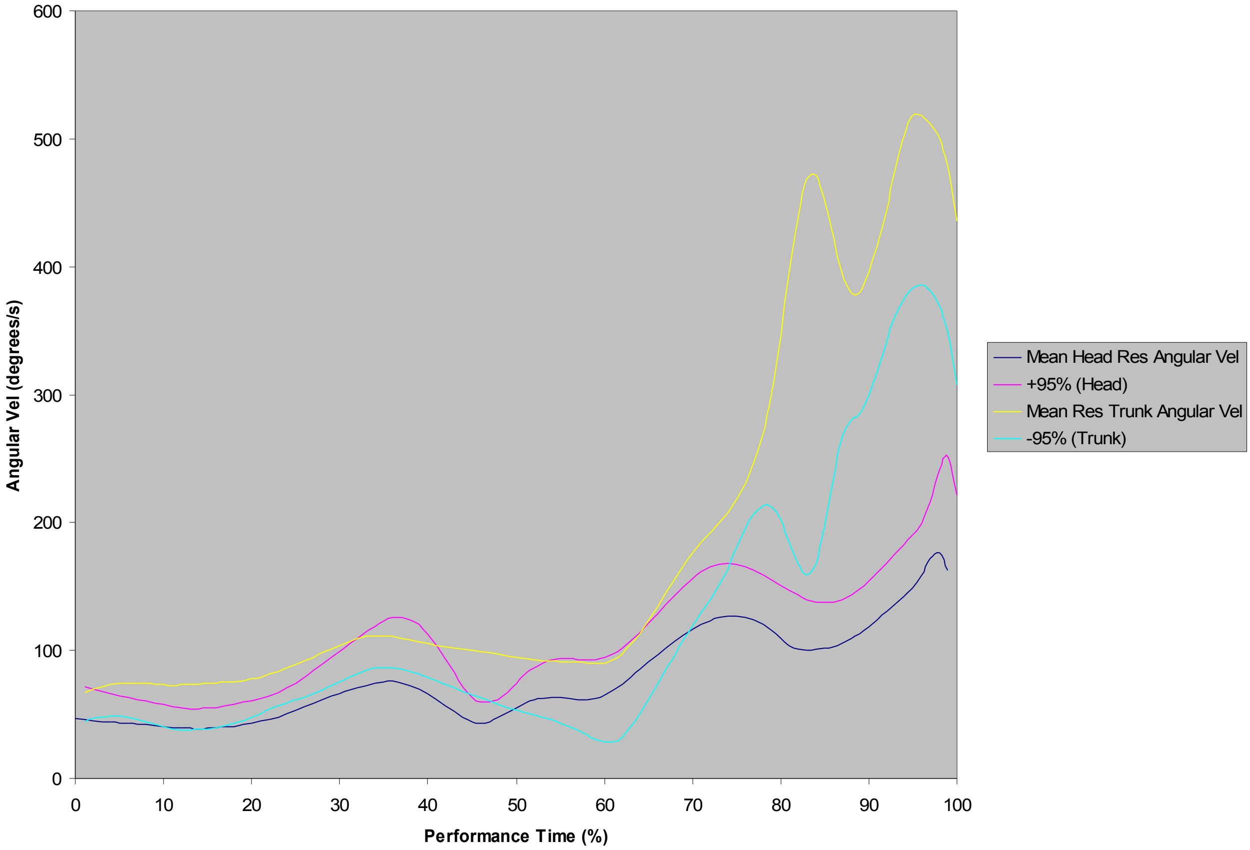

Figure 1 - **Graphical representation of the true means for head and trunk angular velocities across all subjects**

Only moderate levels of positive correlations were found when angular velocities of the head about the external axis were correlated with motor proficiency. When head angular velocities about the trunk axis were contrasted against motor proficiency, only low to moderate levels of positive correlation were attained (See Table 2).

Table 2 **Pearson's Correlation Scores for Each Component**

Component Angular Velocity	Correlation Score
Head with respect to External Axis	
Maximum Somersault	0.44
Maximum Tilt	0.41
Maximum Twist	0.27
Maximum Resultant	0.45
Head with respect to Trunk Axis	
Maximum Somersault	0.22
Maximum Tilt	0.32

Maximum Twist	0.37
Maximum Resultant	0.42

DISCUSSION: The fact that the maximum resultant velocities didn't exceed 350 degrees/s at any time during the performance for any of the subjects implied that the head was stabilised throughout the whole throw. These results supported the findings of Elliot and Leonard (1986) who stated that vision was paramount in targeting activities. This might have occurred to allow visual and vestibular information for the purpose of performance of the skill. It was interesting to note that most of the subjects' maximum head angular velocities occurred near the end of the performance. This suggested that the head was starting to move as part of the 'kinetic chain'.

In view of the moderate positive correlations between the motor proficiency of the subjects and maximum head angular velocities and the positive correlations between motor proficiency scores and maximum head angular velocities with respect to the trunk, there was no evidence from this study to suggest that a relationship existed between motor proficiency and head stabilisation among normal 10 year old children.

These findings contradict those of Larkin and Hoare (1991) who reported a tendency for less motor proficient subjects to not focus on the target during throw. This could be explained by differences in the samples. The subjects in Larkin and Hoare's study were all diagnosed with a form of motor disability whereas the subjects used in this study were normal.

One also needs to consider the possibility that the items in the TGMD were not appropriate indicators of throwing proficiency. Performance-based variables such as a score of accuracy or the speed of the ball might have been more appropriate as measures of proficiency in overarm throwing.

CONCLUSION: In this sample of normal ten year old children subjects stabilised their head throughout the whole performance of an overarm throw towards a target. The head remained stable despite large angular velocities of the trunk near the time of ball release. This implied that the head was stabilised independently of the trunk to provide visual and vestibular information to the performer.

In future research into head movement in overarm throwing a larger sample should be tested. Also, a greater range of motor proficiency within the group should be used. A change in the testing regime for motor proficiency might also show some difference to this study's findings, especially if a score of performance is used

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