EFFECT OF MATCH PLAY ON THE KINEMATICS OF ONE-HANDED STATIONARY NETBALL SHOOTING

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INTRODUCTION

Netball is basically a passing and catching game played by two teams of seven players who share a defined court area. The winner of a netball match is the team which scores the most points. A team scores a point when the ball is "shot" by the team's Goal Shooter or Goal Attack so it passes through a goal ring. The skill of goal shooting is therefore of paramount importance to the final outcome of every match (Brown, 1981).

During a competition netball match shooters are required to repeatedly perform many movement skills to get the ball into the goal circle as well as being responsible for scoring goals. Such movement skills include running, jogging. jumping, passing, catching. guarding, defending, dodging and manoeuvering for position. Anecdotal evidence has suggested that at the completion of a one hour competitive match shooters may experience match tiredness or fatigue that may. in turn, influence their shooting technique. Several studies have examined the effect of fatigue on performance of select skills such as running (eg. Mathis, 1989; Tupa et al., 1991). These studies have shown that performing skills over a prolonged period significantly influenced both the temporal and spatial mechanics of technique performance. However, no studies were located which examined the influence of participating in a competitive netball match on the mechanics of shooting goals. Such information is necessary so coaches can design effective training programs to ensure the duration of match play does not negatively influence shooting accuracy. The purpose of this study was therefore to examine the effect of match play on the kinematics of one-handed stationary shooting performed by highly skilled netball shooters.

METHODOLOGY

Ten highly skilled shooters (mean age = 23 ± 3.4 years) from five teams competing in the 1992 New South Wales Netball (NSW) Association State League Competition (Division 1) were selected as subjects. The sample had a mean shooting experience of 12 years and included six shooters who had been selected in National level teams or squads. Written informed consent was obtained from each subject before testing and all testing was conducted according to the National Health & Medical Research Council Statement of Human Experimentation.

Subjects were filmed performing one-handed stationary shots for goal before and immediately after (within 5 minutes of completing the match) participating in one of their scheduled State League Division 1 competition matches. Each shot was performed 3.0 m from a goal post and adjacent to the goal line in the left-hand sector of the goal circle. The subjects were required to catch a regulation netball, turn to the goal post and execute a standing one-handed shot, while defended, abiding by the All Australia rules governing netball shooting. A minimum of three successful shots per condition (before and after match play) were then recorded. Each shot was filmed from the lateral view using a 16 mm LOCAM Model 5001 high speed camera (100 Hz) positioned with the focal axis of the lens perpendicular to the plane of the shooting motion. A one metre sealing ruler was filmed before each set of trials to enable later conversion of photographic images to actual distance in metres.

The shooting performance of each subject was evaluated during the competition match at which they were filmed to determine the consistency of their shooting accuracy during the match. Shooting accuracy, expressed as a percentage, was calculated for each subject for the first and last game quarters (goals scored/goals attempted X 100). This enabled later calculation of changes in shooting accuracy during match play.

Two successful representative shots, one before and one after the competition match, were selected for analysis for each subject. The shooting movement was divided into four phases: (i) Preparatory Stance: the first frame in which the shooter faced the goal ring, with both feet in contact with the court surface, immediately before initial knee flexion; (ii) Movement Phase I: from the preparatory stance until maximum knee flexion (bottom of "croucli"); (iii) Movement Phase II: from maximum knee flexion until ball release; and

(iv) Release Position: the first frame in which the ball was no longer in contact with the shooter's fingers. Two-dimensional coordinates for 17 reference points per frame representing the anatomical link system and ball were digitised (100 Hz sampling rate) using a Science Accessories Corporation Sonic digitiser interfaced with a President 286 PC and stored on disk for later analysis. Data were smoothed using a second order Butterworth filter (cutoff = 10 Hz) to reduce high frequency noise.

Select kinematic variables (see results) were then calculated in each phase of the shooting action. Means, standard deviations and ranges were calculated for each kinematic and game analysis variable for the 10 shots analysed before and after match play. T-tests for dependent means were then conducted (Statistix Version 3.1) to determine if there was any significant difference ($p < 0.05$) in the shooters' technique before and after match play.

RESULTS AND DISCUSSION

Only results analysed for the shooting action will be discussed below. However, no significant differences were found in the kinematics of the preparatory stance or release position before and after match play in this sample of highly skilled shooters.

Component movements within the shooting action were initiated almost simultaneously by the 10 shooters. That is, on average, only 0.05 sec was recorded between commencing knee extension and extension of the forearm at the elbow. An average of only 0.06 sec was recorded between commencement of forearm extension at the elbow and hand flexion at the wrist. It appears it was not critical to sequentially sum the actions during the shooting action when positioned 3.0 m from the goal post as the need to develop accuracy in shooting far outweighed the need to develop high velocities at release. There was no significant difference in temporal patterning of the movements during the shooting action before and after match play.

Segmental alignment displayed by the subjects at the end of Movement Phase I is presented in Table 1. Results indicated a wide range of knee angle values at the point of maximum "sinking" (knee flexion) both before and after match play. This variability was consistent with the statement that the proper degree of "sinking" at the knees would be established during the shooting action according to the comfort of each individual (Brown. 1981). Adequate knee flexion is, however, necessary to ensure sufficient force can be generated during the netball shot (Elliott & Smith, 1983). However, there was no significant difference between the maximum knee flexion angle before and after match play.

The mean elbow flexion angles before and after match play indicated the shooters displayed greater flexion than that reported for highly skilled shooters by Elliott & Smith (1983) (104.4 degrees). La Point (1980) cautioned that if the elbow was flexed more than 90 degrees. the shot for goal may develop into a throw and sacrifice accuracy. However, the shooters in the present study could achieve successful shots for goal witli a mean elbow angle below 90 degrees. There was no significant difference between elbow flexion angle before and after match play. Furthermore, there was no significant difference in the angle of maximal hyperextension of the hand at the wrist at the end of Movement Phase I before and after match play. Subjects in the present study displayed less hyperextension of the hand than shooters reported by Elliott & Smith (1983; 133.5 degrees) but similar angles to those reported for skilled netball shooters positioned 3.0 m from the post by Otago (1983; mean =

156.20). Excessive hyperextension of the hand at the wrist may be **detrimental** to accurate netball shooting (Elliott & Smith, 1983) and therefore should be discouraged.

Table 1: Segmental alignment at the end of Movement Phase I (end of knee flexion).

	Before		After		
Variable (degrees)	Mean (SD)	Range	Mean (SD)	Range	P
Knee Angle	125.2 ±13.4	96.9-149.0	123.2 213.5	97.4-148.5	0.18
Shoulder Angle	147.2 216.4	118.9-166.6	145.8 ±18.1	115.6-166.7	0.37
Elbow Angle	86.4 214.7	67.2-110.5	87.8 212.6	67.8-110.6	0.43
Wrist Angle	150.4 217.3	123.3-177.3	150.1 ±17.0	122.4-171.5	0.89

Amplitudes of segmental movement displayed by subjects during the shooting action in the present study (see Table 2) were very similar to the average angular displacements recorded during the netball shooting action by previous studies (Elliott & Smith, 1983; Otago, 1983). The amplitude of movement of the three upper extremity segments was also consistent with basketball shooting recommendations. that is, to lessen arm and forearm movements while accentuating hand movements (Baumgartner, 1975). Thus, accentuating hand movement during the shooting action appeared characteristic of skilled netball shooting and did not differ significantly following match play. Angular trunk displacement displayed by the subjects from the end of Movement Phase 1 until ball release (see Table 2) indicated the shooters maintained relatively stationary torsos throughout the shooting action. Minimal trunk movement has been identified as characteristic of skilled netball shooting as excessive trunk motion during the shooting action can interfere with stability and concentration (Elliott & Smith, 1983). There was no significant difference in angular trunk displacement before and after match play. Furthermore, there was no significant difference in the time taken by the shooters from the end of knee flexion to ball release before and after match play. Therefore, match play did not affect either the temporal or spatial characteristics of the movement phases of one-handed shooting performed by this sample of highly skilled netball shooters.

Game Analysis Results: Contrary to expectations, shooting accuracy increased in the last quarter of match play (mean = 72.9%) compared to the first quarter (mean = 62.0%). However, the difference between the means was not statistically significant. Therefore. match play had no consistent effect on shooting accuracy in the five games analysed for the present study.

Table 2: Amplitude of segmental movement (degrees) from the end of Movement Phase I to Release.

	Before		After		
Variable (degrees)	Mean (SD)	Range	Mean (SD)	Range	P

Arm Movement	**10.1 ±7.4**	**2.5-26.3**	**9.1 ±7.0**	**2.2-21.2**	**0.44**
Forearm Movement	**55.6 k14.4**	**36.3-80.2**	**51.9 k17.3**	**21.2-73.8**	**0.48**
Hind Movement	**87.5 ±29.3**	**54.7-153.5**	**88.7 k38.8**	**25.0-157.4**	**0.76**
Trunk Movement	**2.9 ±2.1**	**0.4-7.5**	**2.7 ±1.6**	**0.7-6.0**	**0.60**

CONCLUSIONS

Before this study, anecdotal evidence suggested that the physical and mental demands of **participating** in a competitive netball match may lead to changes in the spatial and **temporal** aspects of shooting. However, **results** of the present study indicated there was no significant difference between the **kinematics** of **one-handed** stationary shooting **performed** by highly skilled shooters, when standing **3.0** m **from** the goal post, before and immediately **after** a competition match. It therefore appeared the **kinematics** of **these** highly **skilled** shooters was sufficiently automated to prevent changes in technique as a consequence of the demands of match play. However, this conclusion is based on changes in shooting performance resulting **from** one competition match per subject. To confirm the present conclusions it is recommended the study be repeated, **analysing** technique changes over a larger number of games per subject. Furthermore, it is suggested a similar ***study*** be conducted but involving less skilled shooters. Less skilled shooters may be less automated in terms of their shooting technique and therefore more susceptible to changes in technique as a consequence of **participating** in a competitive match.

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