THE EFFECTIVENESS OF A SIX-WEEK JUMP SHOT INTERVENTION ON THE KINEMATICS OF NETBALL SHOOTING PERFORMANCE.

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This study measured the kinematics of netball shooting (standing & jump technique) performance throughout a six-week training intervention. Club-class female goal shooters were allocated into three groups - experimental (stand & jump shot training, n=6), training control (standing shot training, n=6) and pure control (no training, n=6). The experimental and training control players underwent a shooting intervention of three sessions (100 shots) per week for six-weeks. All players were tested using two dimensional motion analysis at the start (0 weeks), during (3 weeks), and end (6 weeks) of the intervention programme. The mixed technique program undertaken by the goal shooters in the experimental group was the most beneficial for enhancing overall shooting performance and, therefore, is the recommended strategy from this study for off-season training.

KEY WORDS: netball, shooting, kinematics, training, performance.

INTRODUCTION: Performance success in the game of netball can only be achieved by scoring more goals than the opposing team. Traditionally the static shooting technique (standing shot) has been the most reliable shot for the two attacking players that are permitted within the goal circle. The standing shot is executed from a balanced and stable stance with limited variability. Early shooting actions involved both hands and produced a flat, low trajectory shot which allowed the defenders to easily intercept the ball before reaching the goal. To counteract the actions of the defence, the controlled one-handed shot was developed, which enabled the ball to travel with a higher trajectory (Shakespeare, 1997). Netballs' ancestry began with women's basketball. More recent heightened competition has unsurprisingly led towards intense speculation on utilising a jump shot technique, modified from the technique employed in basketball. It is proposed that an all-purpose netball jump shot could be taken from the outer parameters of the shooting circle, or at close range when clearance of a defensive arm was necessary. With the widespread introduction of the jump shot, the skill of the netball shot could become a competition of speed and skill between the attacking and defensive players within the circle. This could increase the accuracy demands on the netball shooter when also under intense competition pressure. Therefore a sound technical model for the jump shot is needed to guide the development of this skill for netball. The jump shot requires coordination of all body parts (good timing), delicate kinaesthetic touch (fine movements of arm and hand) and powerful, strong and fast leg movements (e.g. Martin, 1981). Further, to maintain accuracy in netball, the shooter needs a smooth and faultless technique, which has the ability to be reproduced with minimal endpoint variability. The purpose of this study was to provide insight on the correct mechanics for the jump shot in netball, as well as a description of technical changes that can be successfully gained with only six-weeks of specific netball training. An additional focus of this study was whether the jump shot technique could be successfully introduced and trained for the game of netball, without disrupting the performance of the traditional standing shot action.

METHOD: Eighteen club netball players (mean age 21.6 ± 4.3 years, height 172 ± 4 cm and mass 71 ± 10 kg) were randomised into three intervention groups of six netball shooters: experimental (EXP -100 shots per training session: 50% jump / 50% standing technique); training control (TC - 100 shots per training session: 100% standing technique); and pure control (PC - No shot training: 0%). The EXP and TC netball shooters underwent a shooting intervention of three sessions per week for six-weeks. Shooting accuracy tests were performed at 0 weeks (pre), 3 weeks (mid), and 6 weeks (post). Two-dimensional video analysis was conducted within a full sized (4.9 m) netball-shooting circle using three Sony digital video cameras (50 Hz). Nine joint markers placed on the right-hand side of the body, enabled the subsequent analysis of the video utilising Silicon Coach Pro Digitiser software (Dunedin, NZ). Video images were digitised from elbow flexion at 90º, through to five frames after ball release. The ankle angle (a) was calculated between the foot and the extension of the shank (full planter flexion = 180º). Knee angle (b) was calculated between the shank and thigh segments (full extension = 180º). Hip angle (c) was calculated as the angle between the thigh and the trunk segments. Trunk angle (d) was calculated with respect to the horizontal plane. Shoulder angles in relation to vertical (e) and in relation to horizontal (f) were calculated between the trunk and the upper arm segments. Elbow angle (g) was calculated between the upper arm and the arm segment, and, the wrist angle (h) was calculated between the arm and the proximal end of the 5th metacarpal. All angles were calculated and smoothed within a custom written MATLAB® data analysis program. A time description of the shooting movement was used to clarify the relationship between various body segments and their contribution to a successful attempt at the goal. To determine the contribution to the movement made by the muscles, the human body model by Hatze (1980) was used. This model enabled changes in both the players' centre of mass (COM), and the contributions of individual segments and the COM to the flight of the netball, to be calculated. COM, jump height and angular velocity (joint, ball) data were calculated in a separate LABVIEW® data analysis program for each of the three testing occasions. Four phases were used in the calculations: 1) Preparation and aiming; 2) Crouch; 3) Execution; and 4) Follow through. All time and velocity measures were log-transformed to reduce bias arising from non-uniformity of error. Proc mixed in the Statistical Analysis System (Version 8.2, SAS Institute, Cary, NC) was used to find significant unequal-variances t statistic comparisons for post-pre differences within and between the experimental and training control groups (Hopkins, 2000). Simple group statistics are presented as means ± between-subject standard deviations.

RESULTS AND DISCUSSION: The focus of this paper was on the technical comparisons between the EXP and TC groups. Further comparisons with the pure control group will be presented elsewhere.

Table 1. Kinematic differences between the traditional standing shot and the new netball jump shot at the pre-test intervention for all 18 netball shooters.

Kinematic variables	Standing Shot	Jump Shot	P value
Maximum ankle angle at release (°)	105.0 ± 10.6	117.0 ± 7.76	0.000
Minimum knee angle at crouch (°)	124.0 ± 20	118.3 ± 22.3	0.015
Minimum hip angle (°)	154.3 ± 10.4	151.0 ± 11.4	0.007
Shoulder angle at release (°)	142.0 ± 15.2	140.0 ± 21	0.025
Total ROM of knee (°)	49.0 ± 25.3	55.2 ± 24.6	0.009
Total ROM of hip (°)	21.1 ± 12.1	24.8 ± 17.38	0.007
ROM of wrist at execution time (s)	18.0 ± 10.0	22.9 ± 10.3	0.970
Ball angle at release (°)	53.4 ± 14.6	55.2 ± 6.8	0.022
Ball velocity at release (m.s-1)	3.11 ± 0.9	2.86 ± 0.7	0.002
Height of release (m)	2.23 ± 0.6	2.31 ± 0.2	0.007
COM change (jump height) (m)	0.23 ± 0.1	0.36 ± 0.2	0.000
Maximum ankle velocity (m.s-1)	0.67 ± 3.2	0.59 ± 1.4	0.002
Maximum knee velocity(m.s-1)	0.65 ± 1.6	0.58 ± 1.8	0.000
Maximum hip velocity (m.s-1)	0.62 ± 1.1	0.56 ± 1.1	0.004

Prior to the training intervention, kinematic differences were identified between the traditional standing shot and the new jump shot in both the EXP and TC groups (see Table 1). The four angles that varied between the two shots were the minimum knee angle (smaller for the jump shot), and the minimum hip angle (smaller for the jump shot) during the crouch phase, as well as the maximum ankle angle (larger in the jump shot) and shoulder angle (smaller for the jump shot) at release. The deeper knee and hip angles at the end of the crouch phase (eccentric-concentric transition of the leg action) and the greater ankle angle at release indicated that a larger impulse was created by the lower extremity during the subsequent execution phase of the jump shot. To achieve optimal results from the momentum generated by the lower extremity action, there should then be a coordinated sequencing of the trunk and upper body action with the ball released at, or very close to the peak of the jump (Adrian & Cooper, 1995). Due to the inexperience of the players with the jump shot technique, a coordinated sequence and higher velocity shot was not observed (e.g. maximum knee velocity ($m.s^{-1}$); stand 0.65, jump 0.58; release velocity ($m.s^{-1}$); stand 3.11, jump 2.86).

Table 2. Significant differences between pre and post-testing occasions, standing and jump shot differences within the experimental group.

Standing shot	**Pre**	**Post**	**P value**
Wrist angle at release (°)	162 ± 18.1	173 ± 16.0	0.015
Minimum hip angle (°)	157 ± 3.9	152 ± 5.0	0.030
Height of release (m)	2.27 ± 0.18	2.41 ± 0.15	0.001
Maximum hip velocity (s)	1.38 ± 0.52	1.83 ± 0.59	0.052
Jump shot	Pre	Post	P value
Maximum knee at crouch (°)	163 ± 11.3	169 ± 7.0	0.047
Minimum total ROM of knee (°)	172 ± 2.5	175 ± 3.4	0.007
Elbow angle at release (°)	143 ± 12.2	150 ± 15.5	0.026
Shoulder angle at release (°)	143 ± 15.1	149 ± 11.4	0.037
Maximum shoulder angle at crouch (°)	145 ± 33.6	154 ± 15.4	0.024
Wrist ROM at execution (°)	22.9 ± 10.3	25.1 ± 10.3	0.556

With six-weeks of technical training (see Tables 2 & 3), both groups (EXP & TC) displayed improved trunk coordination (increased trunk ROM time) within the crouch phase, indicating a possible improvement in the movement sequencing. The EXP groups preparation time increased (6.5%) and the crouch action deepened (greater knee flexion & total ROM); whereas the TC group who undertook no jump shot training, relied upon the strategy of increasing their wrist ROM during the execution phase of the shot, instead of alterations to the leg action. The timing of the key jump shot phases (Table 4) revealed that the improved leg action of the EXP group at the conclusion of the training intervention led to a faster execution phase (pre: 21.7%; post: 16.6%). That is, the body extended more rigorously towards ball release in the EXP group as a result of the increased elastic energy stored during the deeper crouch phase.

Table 3. Significant differences between pre and post-testing occasions, standing and jump shot differences within the training control group.

Standing shot	**Pre**	**Post**	**P value**
Trunk ROM (°)	16.3 ± 8.96	10.7 ± 3.77	0.035
Elbow velocity (m.s-1)	7.06 ± 0.2	7.95 ± 0.21	0.255
Jump shot	Pre	Post	P value
Wrist ROM at execution (°)	22.9 ± 13.0	25.1±8.7	0.336

Specific alterations to the execution phase of the jump shot with training (EXP group) included an increase in the shooters shoulder angle at the end of the crouch and at release. Overall, the shooting arm was held higher with the elbow more extended which is advantageous for obtaining greater release height (Adrian & Cooper, 1995). Extension of the elbow joint occurred at a time close to ball release for both techniques and groups (EXP & TC). However, after training, the forearm moved more vigourously upwards and slightly backwards just prior to release in the jump shot, producing a faster forearm action. Adequate but not excessive wrist ROM should be observed towards the end of the execution phase to stabilise the ball prior to release (see Table 2), however hyperextension of the wrist can increase the likelihood of an uncontrolled shot (Elliott & Shakespeare, 1983). The wrist ROM of the EXP group increased for the jump shot (pre: 22.90, post: 25.10). Large velocity of the wrist in the execution phase is important (Elliott, 1991), therefore the larger wrist ROM helps increase the wrist angular velocity if there is vigorous enough flexion of the wrist. A more rigorous wrist flexion action should result in higher velocity of the fingers and therefore the ball.

Table 4. Mean and SD values for the timing of individual phases within the netball shot for pre and post intervention testing. The abbreviation * denotes a significant difference of p<0.05.

	Prep phase time (s)	Crouch phase time (s)	Execution phase time (s)	Shot time (s)	Prep phase time % of shot time	Crouch phase time % of shot time	Execution phase time % of shot time
Exp Jump Pre	0.41 ± 0.12	0.26 ± 0.05	0.8 ± 22.0	1.4 ± 0.6	45.9 *	32.6	21.7 *
Exp Jump Post	0.52 ± 0.18	0.27 ± 0.06	0.9 ± 16.5	1.7 ± 0.4	52.2 *	31.3	16.6 *
Exp Stand Pre	0.39 ± 0.15	0.24 ± 0.59	1.1 ± 40.4	1.6 ± 0.5	66.7 *	25.9 *	7.4
Exp Stand Post	0.46 ± 0.25	0.27 ± 0.08	0.9 ± 16.6	1.6 ± 0.4	52.1	30.3	17.7
TC Stand Pre	0.56 ± 0.18	0.25 ± 0.04	0.7 ± 15.4	1.5 ± 0.4	45.9 *	37.1*	17.0
TC Stand Post	0.51 ± 0.18	0.26 ± 0.04	0.7 ± 18.8	1.5 ± 0.2	45.8	36.0	18.2

The correct mechanics for the jump shot in netball was a primary interest, however it was also important to identify whether this new technique would either disrupt existing performance or whether the mixed technique training would result in superior overall shooting performance. The EXP group experienced three positive changes in the standing shot technique compared to the TC group. The wrist ROM increased during the execution phase, creating greater ball release velocity. Increased COM and ball release height was also observed, indicating that the EXP group had a higher point of release after the training intervention – despite their lower physical height (by an average of 14 cm). A greater release height would provide a higher entry angle and shorter ball trajectory, resulting in decreased end point (target) variability and increased standing shot performance.

CONCLUSION: Training shooters to use the jump shot should enable them to leave the ground and still shoot successfully when required to, for example, counteract a jumping defence. The recommended strategy is to use a mixed technique training intervention during the off-season to increase netball shooting performance. Due to limited research, the full efficiency of the netball jump shot is unknown, and the teaching / application of the netball jump shot is still relatively undefined. However, it appears that a greater release height and release velocity contributes to more successful shooting.

REFERENCES:

Adrian, M.J. & Cooper, J.M. (1995). Biomechanics of human movement. Brown and Benchmark, U.S.A.

Elliott, B. (1991). The jump shot: A comparison of male and female shooting techniques. Australian Sports Commission, Canberra, Australia.

Elliott, B. & Shakespeare, W. (1983). Netball shooting: A statistical analysis. Sports Coach, 7, 29-30.

Hatze, H. (1980). A mathematical model for the computational determination of parameter values of anthropometric segments. Journal of Biomechanics, 14, 135-141

Hopkins, W.G (2000). A new view of statistics, Sport Science, New Zealand 2000.

Martin, T.P. (1981). Movement analysis applied to the basketball jump shot. The Physical Educator, 38, 127-133.

Shakespeare, W. (1997). Netball: Steps to Success. Human Kinetics, USA.