BALL SIZE AND PERFORMANCE

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Basketball is one sport where equipment design research has been almost nonexistent. With the exception of a height-adjustable basket and a junior-sized ball for elementary players, the size and weight of the first official basketball has remained the same for college men and women since its initial production in 1941 (Pitts, 1985). It has been suggested that skill performance by women may be limited in those sports which do not have modified equipment designed specifically for their use (Eason, 1962; Pitts, 1985). The literature attributes differences in height, weight, hand size, and upper body strength between males and females to be responsible for a "handicapped" performance by women (as compared to men) when using equipment originally designed for men (Easson 1978, Husak 1984, Daily & Harris 1984, Critelli 1984, and Pitts 1985).

The rationale behind the adoption of the smaller ball for woman was that the regulation ball was too large and too heavy for women to perform as well as men. Critteli (1984) has claimed that the use of a smaller, lighter basketball in the women's game improved ball handling, passing, shooting, dribbling, and air-borne manipulation. Her report stated that "women are playing with a basketball too large for their hands" and that their upper body strength was not sufficient to handle the regulation basketball. When compared to the men's game, women seem to play in a "slightly awkward" fashion. Her statements were based on two recent studies (Husak, 1984; and Daily & Harris, 1984) which focus on the immediate performance of women basketball players using a smaller sized ball.

This study has attempted to add to the existing knowledge on the effects ball size and weight may have on basketball performance at the intercollegiate level. An attempt was made to determine if hand size and arm strength were limiting factors in the game of basketball for women and men. Unlike previous studies, a third weight modified ball was tested with the large and small balls. This enabled the authors to determine whether observed differences in skill performance were the result of smaller ball size, reduced weight, or a combination of these factors.

METHODS AND PROCEDURES

Subject Selection

Seventy-one female and thirty-five male CIAU intercollegiate basektball players volunteered as subjects for this study. All participants had used the larger CIAU regulation ball during their regular season play; and all female participants had played with the smaller ball prior to joining their university varsity team. Testing was conducted in a gymnasium when each team came to play exhibition or regular season games at the University of Alberta. Written permission from the head coach of each basketball team was received prior to testing. Testing was conducted in two phases. The first phase examined hand size and wrist and arm strength. The second phase tested skill performance and subjective examination of the test balls.

Each subject's dominant hand was measured for length, width, and palm area as shown in Figure 1. These measures were made from a ball specific hand print. Players were required to ink the palm surface of their dominant hand and position that hand on a regulation-sized basketball as they would when dribbling or shooting. As players held their fingers still, an assistant carefully removed their configured hand to the back of that player's data collection sheet where their palm print was made. This print simulated the fingers and thumb of the player's hand in a configuration that was normally used when shooting or dribbling a regulation-sized basketball. Figure 2 exhibits how a ball specific hand print was obtained. The three hand measurements were calculated using a MOP-3 pen stylus digitizer (Carl Zeiss Inc.).

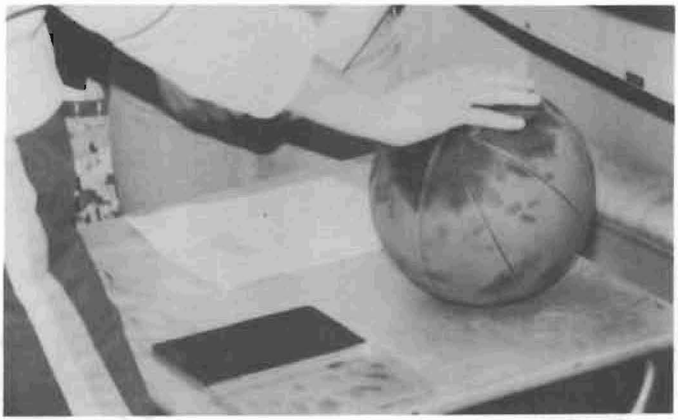

Figure 1., Obtaining a Ball Specific Hand Print

Arm Strength

The primary action observed in most basketball skills is adduction of the shoulder, extension of the elbow, and flexion of the wrist. With this in mind, general arm extension and wrist flexion were measured. Each subject performed a maximal effort arm extension on a modified Hydra-Gym, omnikinetic leg extension/flexion dynamometer. Participants were asked to position their hands on the T-bar leaver as if they were about to throw a chest pass in basketball (Figure 3). They were subsequently asked to extend their arms as forcefully and as quickly as possible to full extension. This action of arm extension was intended to simulate a chest pass in basketball. The maximum torque a player could exert during the action of arm extension was determined by performing this action. The best of three peak-torque readings was recorded as maximal arm strength.

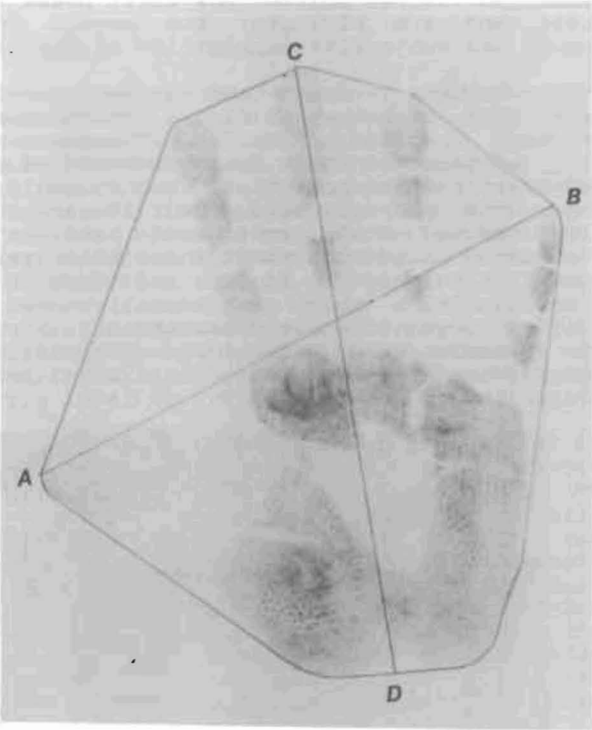

Figure 2., Ball Specific Hand Print

Hand Area=area inside line tracing perimiter of hand
Hand Length=length of line C-D
Hand Width=lengthof line A-B

Figure 3., Arm Strength Assessment

Wrist Strength

All subjects performed a maximal effort wrist flexion with their shooting hand on a Cybex II, isokinetic dynamometer set at a speed of 60 degrees per second (Figure 4). The best of three peak-torque readings were recorded as the player's maximum wrist strength. These values were determined from strip chart records of the wrist torques. The action of wrist flexion was examined because it simulated the action of the wrist used in dribbling and shooting a basketball. Both the Cybex II and the modified Hydra-Gym dynamometers were routinely calibrated prior to each test session.

Figure 4., Wrist Strength Assessment

Basketball Skill Tests

A battery of five basketball skill tests were employed in this study. These tests were similar to those used by Husak, (1984), and Dailey and Harris, (1984). A description of these tests and their intraclass correlation coeffitients (r) (Hopkins, 1979; Dailey & Harris, 1984) are listed below.

1. Lay-up (0.90)* The purpose of this test was to examine rebounding ability. Each subject was asked to put the ball into the basket as rapidly as possible in 30 seconds. For each basket made one point was scored.

2. Side shot (0.86)* The purpose of this test was to measure a player's shooting ability. Fifteen trials were taken with each ball from a spot outside the free throw line and circle facing the basket on the left or the right. Two points were scored for every basket made without the basketball touching the backboard. One point was scored for a shot which hit the rim (before hitting the backboard) but did not go in. All missed shots scored zero points. A maximum of 30 points was possible.

3. Speed pass (0.89)* This test measureed a player's sending and receiving skills. Each participant was instructed to pass a basketball against a wall and catch it as quickly as possible ten consecutive times from a distance of nine feet. Time was recorded to the nearest tenth of a second.

4. Dribble (0.91)* The purpose of this test was to examine dribbling ability. Each subject was instructed to weave through six cones down and back dribbling a basketball for a total distance of 90 feet with either hand. The time to compleate the circute was recorded as the score.

5. Figure-8 (0.87)** The purpose of this test was to examine how well a player could control a basketball. Subjects were asked to move a basketball around their legs in a Fig-8 pattern as quickly as was possible without losing control of the ball. The number of cycles completed in 30 seconds was recorded as the score.

After all the subjects had been measured for hand size and strength, they were paired with a second subject and instructed to travel from station to station to perform each skill test. A short practice period was allowed each subject to provide familiarity with the task. Each subject performed each test with each of the three balls. The order of use of the three

* From the AAHPER test battery (1966), used by Husak (1984).
** From Dailey and Harris, (1984).

TABLE III
CORRELATION MATRIX OF
PHYSICAL FACTORS VS BASKETBALL SKILL PERFORMANCE FOR MEN

BALL TYPE	SKILL TEST	HAND AREA	HAND LENGTH	HAND WIDTH	ARM STRENGTH	WRIST STRENGTH
A	SIDE SHOT	0.1525	0.3131	-0.1079	-0.0668	0.0186
B	SIDE SHOT	-0.0614	0.1091	-0.1961	-0.1856	0.0332
C	SIDE SHOT	0.0527	0.1159	0.0105	0.0823	0.1120
A	LAY UP	0.2918	0.2572	0.1789	0.2571	-0.1659
B	LAY UP	0.1853	0.0150	0.2542	-0.0664	-0.1050
C	LAY UP	0.2691	0.2825	0.1322	0.2125	-0.2026
A	FIGURE-8	-0.0836	0.1301	-0.3149	-0.0472	-0.3046
B	FIGURE-8	-0.1590	0.1090	-0.4484**	-0.1021	-0.2090
C	FIGURE-8	-0.2100	-0.0264	-0.4347**	-0.0588	-0.3883*
A	DRIBBLE	0.1226	0.0886	0.1483	-0.1902	0.0342
B	DRIBBLE	-0.0352	-0.0713	0.0299	-0.3220	-0.1559
C	DRIBBLE	0.1170	0.1030	0.0973	-0.0972	0.0742
A	SPEED PASS	0.0453	0.0219	0.0047	-0.2740	0.1378
B	SPEED PASS	0.0576	-0.0407	-0.0618	-0.2853	0.1481
C	SPEED PASS	0.0142	-0.0080	0.0840	-0.3036	0.1545

* p<0.05 @ 34 df
** p<0.01 @ 34 df

Significant relationships were found to exist between upper body strength and performance in shooting, dribbling and ball manipulation. The correlation analysis revealed results which both agree and disagree with the findings of previous studies. The significant relationship observed between shooting performance and wrist strength for the two heavy balls, ball types "A" and "C", indicated wrist strength and shooting performance were related for women players using heavier basketballs. However, wrist strength was not related with the shooting performance of intercollegiate women using the smaller ball. This result is in opposition to the results of Pitts (1985) which reports significant correlations ($p<0.05$) between grip strength (reported to be a good measure of wrist flexion) and performance in shooting for both the small and large ball for college and high school women. A possible explanation of this result could be that there is a "critical ball weight" at which wrist strength is related to shooting success. Basketballs below this critical weight may not effect shooting performance from the free throw line however, ball weights above the critical value could affect shooting performance.

A significant positive correlation between wrist strength and dribbling performance with only the large, heavy ball indicates wrist strength may have an effect on ball control when a player dribbles a large, heavy ball. This result disagrees with the finding of Pitts (1985) which reports a negative correlation between grip strength and dribbling performance for college and high school women using both the large and small ball.

A significant correlation between arm strength and figure-8 performance using ball "A" and non-significant correlations between the same two factors with balls "B" and "C" indicate that there is not a relationship between arm strength and either ball size or weight for intercollegiate women in the figure-8 skill test.

Hand size, defined as palm surface area and hand width (line A-B in Figure 1), was found to correlate significantly with ball control/manipulation in the figure-8 and dribble skill tests and sending/receiving skills in the speed pass test. The finding of a significant negative correlation of hand width with ball control in the figure-8 test for balls "A" and "B" was difficult to interpret. A possible explanation of this result could be that the farther players spread their fingers, as indicated by the hand width measure, the flatter and stiffer the palm surface of the hand becomes. This might result in decreased ball control and thus a lower score when performing the figure-8 skill test.

Hand area and width were significantlly related with ball control while dribbling for all three ball types. The wider players spread their fingers, the larger the hand contact base area becomes, enabling a player to have better ball control when dribbling a basketball. However, the authors hypothesize that when players spread their fingers beyond an optimal limit, forearm muscle tension increases to impede free wrist flexion. This could hinder ball control when dribbling. The result discussed here supports the conclusions of Beall (1939) which found hand size to have a significant influence on shooting and ball control in basketball.

Significant negative correlations were found for hand area and speed pass performance with the two heavy balls, balls "A" and "C". The larger the hand area, the slower the times were for speed pass performance by women. This result parallels the observation of Pitts (1985). She observed a significant negative relationship between hand size and speed pass performance for both large and small balls. A possible explanation of this result could be that a smaller finger tip radius is better for passing a basketball fast and efficiently. This finger position could be similar to the style used to "set" a volleyball. Players passing a basketball off the palm of their hands utilize only the propulsive forces of arm extension and wrist flexion. Ball velocity is increased when players additionally propel the ball with quick flexion of the fingers. Players can optimize the speed of a pass by curling their fingers to reduce the finger tip radius and therefore gain the mechanical advantage neccessary to forcefully extend their fingers.

CONCLUSIONS

Within the limitations of this study, the obtained results led to the following conclusions:

1. Passing speed was found to increase when CIAU women and men used the small light ball. It was concluded that ball weight reduction enhanced passing performance.

2. Dribbling speed was found to increase when CIAU women used the large heavy ball. It was concluded that ball size reduction detracted from bribbling performance.

3. Since passing and dribbling include both sending and receiving skills, it seems possible that a change in ball size and weight has offsetting effects on basketball performance. An optimal ball size and weight has not been determined for use by intercollegiate players.

4. The weighted small ball was found not to improve performance in any of the five skill tests examined. This ball would not be suitable as an alternative to the larger basketball currently used for CIAU intercollegiate play.

5. Men performed equally well with all test balls in all skill tests but the speed pass. It is possible that there is a "critical ball weight" at which strength is related to success in basketball. For example it might be that basketballs below this critical weight may not effect foul shot performance, however, ball weights above the "critical value" could affect shooting performance from the free throw line.

6. The importance of the finger spread of a players' hand while handling a basketball was highlighted in three ways.

a. Hand area and width were found to correlate significantly with performance in the dribbling skill test by intercollegiate women. The wider players fan their fingers, the greater the hand contact area becomes. This enables a player to command better ball control when manipulating, dribbling or catching a basketball. However, it is possible for players to spread their fingers beyond an optimal limit which is specific to each player. This over spreading of the fingers increases forearm muscle tension which impedes free wrist flexion and hinders ball control when dribbling.

b. Hand width was found to negatively correlate with ball control/manipulation in the figure-8 skill test for women. It is possible that the farther players spread their fingers, as indicated by the hand width measure, the flatter and stiffer the palm surface of the hand becomes. This, together with an increased muscle tension of the forearm, might result in decreased ball control and thus a lower score when performing the figure-8 skill test.

c. Significant negative correlations were found for hand area and speed pass performance with the two heavy test balls.

A possible explanation of this result could be that a smaller finger tip radius is better for passing a basketball fast and efficiently. This finger position could be similar to the style used to "set" a volleyball. Players passing a basketball off the palm of their hands utilize only the propulsive forces of the arm extension and wrist flexion. Ball velocity can be increased when players additionally propel the ball with a quick flexion of the fingers. Players can optimize the speed of a pass by curling their fingers to reduce the finger tip radius and therefore gain the mechanical advantage neccessary to release the ball forcefully from the finger tips.

7. Wrist strength appears to have a greater infulence on shooting and dribbling than does arm strength. It is probable that the precision players require when shooting free throw shots is introduced by specific actions of the wrist and fingers.

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