COMPARISON OF ADULT MALE AND FEMALE PERFORMANCE ON THE BASKETBALL FREE THROW TO THAT OF ADOLESCENT BOYS

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Modifying the adult version of competitive sports by adjusting the rules and/or playing environment for smaller and younger players is a common practice followed throughout the United States by many youth sport organizations. It has been suggested that such modifications increase the player's level of success as well as enjoyment of the game (Seefeldt & Gould, 1980). Whether or not these changes facilitate development of the fundamental skills associated with the sport is a question yet to be addressed in the literature, however. Adult models are often used as the standard against which teachers and coaches involved with young players measure their development and, ultimately, their performance. Movement patterns demonstrated by adults and adolescents under regulation and/or modified conditions have not been compared. The purpose of this study, therefore, was to compare selected performance parameters of skilled adult male and female collegiate players to that of seventh grade boys shooting with two different ball sizes at two basket heights.

Methods

Subjects

Seventh grade boys enrolled in physical education classes at a public junior high school and male and female members of the 1986-87 Kansas State University basketball teams volunteered to participate in this investigation. Descriptive data on the adolescents, males, and females who participated are presented in Table 1. Consent forms wer signed by all subjects and by the parents of the adolescents.

Table 1

Subject Descriptive Data

Adolescents	Age (yrs)	Ht (cm)	Wt (N)
9 Q	13.00	160.0	444.9
11 U	12.92	152.4	396.0
Adult Females			
F01	21.17	164.0	531.8
F08	18.83	173.4	649.7
Adult Males			
M14	19.00	184.1	776.5
M15	21.42	193.2	983.5

Procedures

The sagittal view of successful free throws was filmed with a model 51, 16 mm, pin-registered Locam camera. Film transport speed was set at 100 fps to record repeated trials for each subject. The adolescents used two ball sizes at two basket heights. The intermediate (weight = 4.82 N, circumference = 72.1 cm) and regulation college men (weight = 5.85 N, circumference = 75.4 cm) were the two ball sizes used. The regulation height of 10 ft (3 m) and a basket lowered to a height of 8 ft 2.4 m) were the two basket heights used. The adults used the appropriate competitive ball size for their gender (males = 5.85 N, 75.4 cm; females = 5.07 N, 73.4 cm).

All trials were coded using a 4-point rating system according to whether it was successful (4-3-2) or unsuccessful (1-0) (Pangman, 1982). Similar types of successful trials were selected for analysis and comparison across all subjects. A model 1224 Numonics digitizer interfaced with an Apple II+ microcomputer and software written by Richards and Wilkerson (1984) recorded x- and y- coordinates of 19 segmental endpoints and ball center for the adolescent performers. Raw data were smoothed using a cubic spline function (weight vector (DF) = .15). A Graf/Pen sonic digitizer interfaced to a Zenith Z-100 PC series microcomputer and software written by Noble, Zollman, and Yu (1988) recorded the same coordinates for the adult performers. Raw data were smoothed using a low-pass digital filter with a cutoff frequency individually determined for each digitized point based on a Harmonic analysis of the raw data (Noble et al., 1988).

Data Analysis

Two successful trials (coded as "4") per adolescent under each of the four environmental conditions and four successful trials per adult were analyzed. Each subject's scores were averaged for comparison of the following selected parameters: (a) angle of projection of the basketball, (B) linear velocity of the basketball at release, and (c) timing and coordination of the knee, shoulder, elbow, and wrist joints during the free throw shooting motion.

Results

Higher angles of projection were used by the adults (M=52.1 deg, F=54.8 deg) than by the adolescents at either basket height (A_{10} = 48.6 deg, A_8 = 46.7 deg). Lower linear velocities at projection were used by the adults (M=6.00 m/s, F=6.48 m/s) than by the adolescents (A=6.82 m/s).

Similar timing and coordination of the knee, shoulder, elbow, and wrist joints were demonstrated by the adolescents across the four environmental conditions. Table 2 contains time data for joint reversal relative to ball release for these subjects. Since the timing and coordination patterns were similar across the four basket height and ball size combinations, only the patterns demonstrated under the regulation condition (10-foot basket, regulation size basketball) are presented (Figures 1 and 2).

Table 2

Joint Reversal Relative to Ball Release--Adolescents

9 Q	10-R[a]	10-I	8-R	8-I
Knee	-.28[b]	-.28	-.26	-.26
Shoulder	-.26	-.30	-.30	-.28
Elbow	-.22	-.22	-.22	-.22
Wrist	-.08	-.08	-.06	-.08
11 U				
Knee	-.24	-.24	-.24	-.24
Shoulder	-.20	-.20	-.20	-.26
Elbow	-.20	-.16	-.16	-.14
Wrist	-.04	-.06	-.06	-.04

[a] 10 - R = 10-foot basket, regulation size basketball
10 - I = 10-foot basket, intermediate size basketball
8 - R = 8-foot basket, regulation size basketball
8 - I = 8-foot basket, intermediate size basketball

[b] time is in seconds.

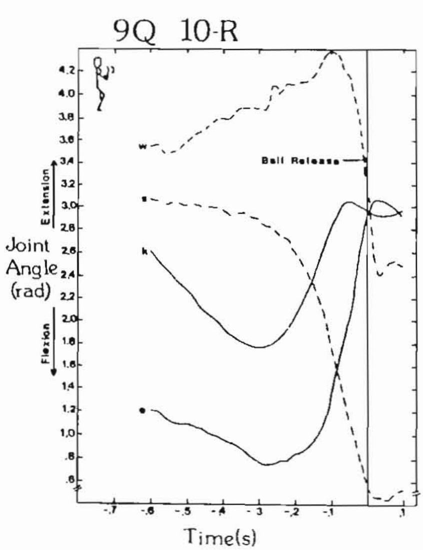

Figure 1. Adolescent 9 Q.

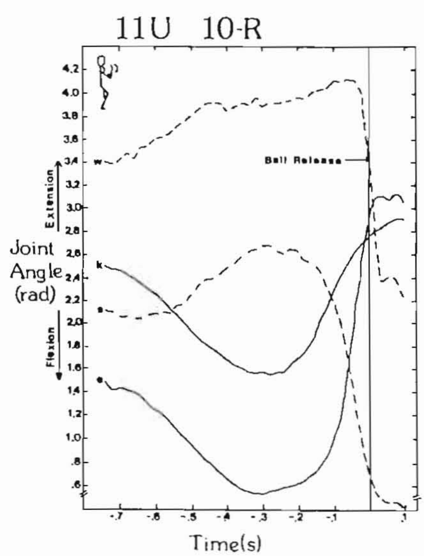

Figure 2. Adolescent 11 U.

Time data for joint reversal relative to ball release for the adult performers showed similar timing for the knee, elbow, and wrist joints to that demonstrated by the adolescents. The shoulder was used differently, however (Table 3 and Figures 3-6). For the adolescents, shoulder flexion relative to ball release occurred around the same time as knee and elbow extension (Table 2). For the adults, however, discernable shoulder flexion occurred earlier in the shooting motion-between .2 to .3 s prior to knee and/or elbow extension (Table 3). Only one of the six subjects (F01, Table 3, and Figure 3) demonstrated simultaneous extension of the knee and elbow joints. Knee extension occurred prior to elbow extension in the remaining five subjects, ranging from .06 s difference for the two adolescents (Figures 1 and 2) to .08 s for F08 (Figure 4) and M15 (Figure 6) to .12 s for M14 (Table 3 and Figure 5).

Table 3

Joint Reversal Relative to Ball Release--Adults

	F01	F08	M14	M15
Knee	-.22	-.32	-.24	-.32
Shoulder	-.52	-.66	-.48	-.52
Elbow	-.22	-.24	-.12	-.24
Wrist	-.10	xxxx[a]	-.04	-.08

[a]missing data.

Although similar timing and coordination patterns were demonstrated across the adolescents and adults, differences in magnitudes of the joint angles at the time of joint reversal and at ball release were noted (Tables 4 and 5). At joint reversal, the adolescents and F08 demonstrated greater knee flexion (1.59-1.77 rad) than for F01 and the males (2.00-2,15 rad). The adolescents and F01 demonstrated greater elbow flexion (.65-.80 rad) than F08 and the males (1.00-1.34 rad). The adolescents and females had greater extension at the shoulder (2.60-2.90 rad) than did the males (1.64-1.80 rad). M14 had less wrist hyperextension (3.40 rad) than the other subjects. At ball release, similar knee extension across subjects was demonstrated. The elbow was more extended for the adolescents (2.84-2.91 rad) than for the females and M15 (2.42-2.52 rad). M14 had the least elbow extension (2.26 rad). The shoulder was more flexed for the adolescents (.62-.76 rad) than for the males (.92-.97 rad) or the females (1.06-1.11 rad). M14

had the greatest wrist flexion at release (2.50 rad). The adolescents and F08 moved through a greater range of motion at the knee (1.16-1.28 and 1.41 rad) than F01 and the males (.71-.99 rad). The adolescents also had a greater range of motion at the elbow (2.04-2.26 rad) than the adults (1.07-1.72). The adolescents and females had a greater range of motion at the shoulder (1.49-2.20 rad) than the males (.67-.88 rad). The males and 9-Q had a greater range of motion at the wrist (.90-.97 rad) than did 11-U and F01 (.56-.59 rad).
Figure 3,4

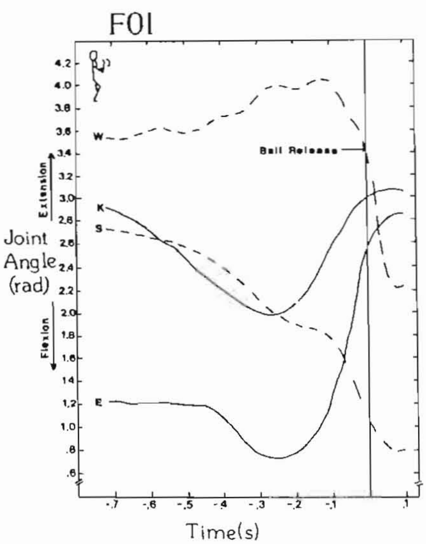

Figure 3. Adult Female F01.

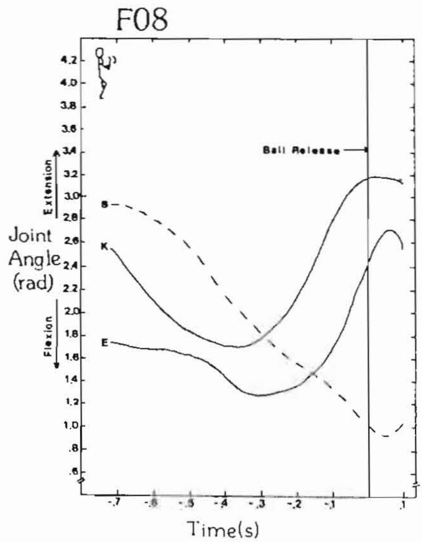

Figure 4. Adult Female F08.

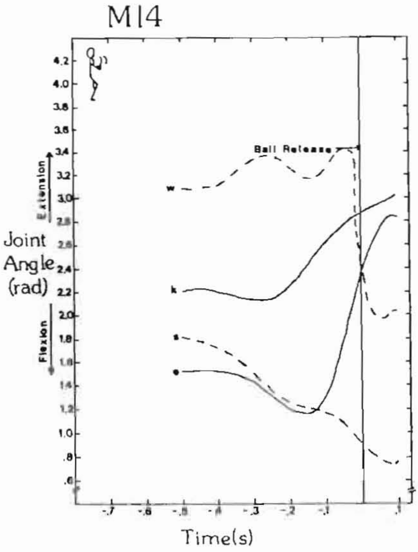

Figure 5. Adult Male M14.

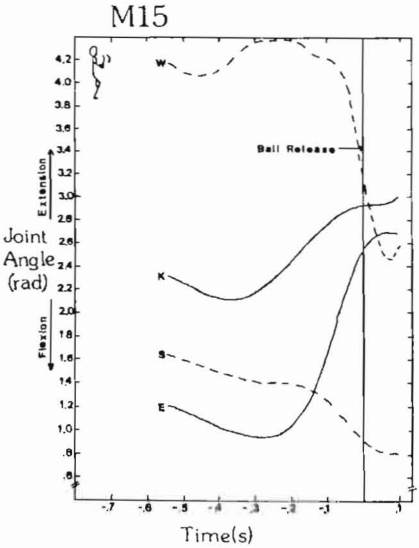

Figure 6. Adult Male M15.

Table 4

Joint Angle (rad) at Time of Joint Reversal

	9-Q	11-U	F01	F08	M14	M15
Knee	1.70	1.59	2.00	1.77	2.14	2.15
Shoulder	2.82	2.63	2.60	2.90	1.80	1.64
Elbow	.80	.65	.77	1.34	1.19	1.00
Wrist	4.28	4.09	4.00	xxxx[a]	3.40	4.19

[a]missing data.

Table 5

Joint Angle (rad) at Ball Release

	9-Q	11-U	F01	F08	M14	M15
Knee	2.98	2.75	2.99	3.18	2.85	2.93
Shoulder	.62	.76	1.11	1.06	.92	.97
Elbow	2.84	2.91	2.49	2.42	2.26	2.52
Wrist	3.34	3.50	3.44	xxxx[a]	2.50	3.22

[a]missing data.

Discussion

Similar types of successful free throws were compared across subjects. Free throws that passed through the hoop without hitting the backboard or rim were coded "4" and selected for analysis. The adolescents used a lower projection angle and accompanying higher projection velocity than the adults. Projection angle and velocity at ball release represent the end result of the player's shooting motion. To adequately compare free throws of the adolescents with those of the adults, it is necessary to look at the timing and coordination of the joint actions of the upper and lower body that allow the subjects to accomplish their task of putting the ball through the basket.

Changing the size of the basketball and/or height of the basket did not have a great effect on the relative timing and coordination of the knee, shoulder, elbow, and wrist joints of the adolescents. This finding suggests that the subjects had established a motor pattern for the basketball free throw. Changing the parameters that determine the manner in which the movement will be carried out depends upon the demands placed upon the program by the size of the ball and/or height of the basket but does not change the pattern (Satern, Messier, & Keller-McNulty, in revision). The relative timing and coordination of the joint actions was not greatly affected, therefore, but the magnitudes and range of motion of the point actions changed as the parameters changed.

When the motor pattern for the adolescents was compared to those demonstrated by successful adult male and female players, the overall sequence and timing of joint actions was similar. Some subtle differences were noted, however. The sequence followed by the adults during the action portion of the free throw (from joint reversal through ball release) was that of shoulder flexion, then knee extension followed quickly by elbow extension, with wrist flexion occurring just prior to ball release (Table 3). Subject 9-Q followed this sequence under the three modified conditions as did 11-U under the most modified condition (8-foot basket, intermediate size ball). Knee extension initiated the sequence of joint actions for the adolescents under the remaining conditions, however (Table 2). This finding suggests that the modifications did seem to help simulate a comparable environment to that of the adults, but not a completely comparable one as the differences were very subtle.

A closer linking of joint actions between the knee and elbow was noted for the adolescents and F01 than for F08 and the males. In addition, shoulder action was linked with the knee and elbow for the adolescents (Figures 1-3). Since these three subjects were shorter and lighter than the other three, this linkage suggests that a summation of forces was needed for these subjects to successfully project the basketball through the hoop. Indeed, these subjects were also noted to have the greatest range of motion at the knee and elbow joints. The males and F08 moved the knee and elbow more independently of each other (Figures 4-6). In addition, the males had less range of motion at the shoulder, knee, and elbow, but a greater range of motion at the wrist than did the females and adolescents. This finding suggests that the males used their wrist more to generate the force necessary to successfully complete the task.

Many teachers and coaches suggest that the free throw shooting motion should be as "compact" (meaning little motion) as possible. Indeed, the reduced range of motion demonstrated by the males suggests that they were able to accomplish this task using a compact shooting motion. M15, the tallest and heaviest of all the subjects, used a movement pattern that was mostly wrist and elbow with very little shoulder movement. On the other hand, the adolescents and females, who were smaller and lighter required greater involvement of the knee and shoulder and moved all the joints through a greater range of motion to successfully accomplish the task.

Conclusions

The results of this study suggest that similar timing of the knee, shoulder, elbow, and wrist joints is used across individuals to successfully execute free throws in the sport of basketball. Ball size, basket height, subject height, and subject weight may affect the magnitude of the joint actions at joint reversal and at ball release as well as the sequence of timing relative to ball release. The subjects of this investigation demonstrated a tighter linkage between the knee and elbow for the adolescents and one female than for the other female and males. In addition, shoulder action was linked with knee and elbow action in the adolescents. Smaller and lighter players required greater involvement of upper and lower body parts than did taller and heavier players to successfully accomplish the same movement task.

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