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THE ROLE OF ROTATIONAL MOBILITY AND POWER ON THROWING VELOCITY

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ABSTRACT

Talukdar, K, Cronin, J, Zois, J, and Sharp, AP. The role of rotational mobility and power on throwing velocity. *J Strength Cond Res* 29(4): 905–911, 2015—Sound rotational power and mobility are an integral component in functional performances, such as throwing and striking. The purpose of this study was to examine the role of rotational power and mobility on cricket ball–throwing velocity. Eleven professional cricketers and 10 under-19 club-level cricketers performed the chop and lift, seated and standing cricket ball throw, seated and standing side medicine ball throw, and seated active thoracic rotation range of motion (ROM) and hip rotation ROM on one occasion. Participants were divided into 2 groups (fast and slow) based on their standing cricket ball–throwing velocity. The seated and standing cricket ball throw on the dominant side was significantly different ($p < 0.00$) between fast and slow throwers (11.03 and 10.7 $km \cdot h^{-1}$, respectively). Muscular performance measures, such as bilateral thoracic rotation ROM, hip external rotation ROM on the dominant side, and force and work required in the chop, were significantly different ($p \leq 0.05$) between fast and slow throwers. Faster throwers in this study displayed greater force (18.4%) and work (31.2%) outputs in the chop compared with the slower throwers; however, slower throwers showed significantly greater ROM in the thoracic (13.4–16.8%) and hip regions (11.8%). It was concluded that greater ROM at proximal segments, such as hips and thoracic, may not increase throwing velocity in cricket as reduced ROM at proximal segments can be useful in transferring the momentum from the lower extremity in an explosive task such as throwing.

KEY WORDS proximal segment, muscular performance measure

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INTRODUCTION

Batting, bowling, and fielding can be considered to be the 3 pillars of cricket. Of interest is the fielding component of the game, in particular the throwing aspect of cricket. The ability of players to consistently throw at high velocity, with accuracy, is considered to be a challenging task that can influence the outcome of a game (1). Improved force output and rate of force development in the appropriate muscles can result in increased throwing velocity (14). Because of the kinetic linkage of the proximal to distal sequence in throwing (17), it is important for the force to be transferred sequentially from the proximal segments, such as the hips, toward the more distal segments, such as the shoulders and arms. Therefore, the optimum mobility and power transference of the proximal segments, such as the hips and upper trunk, may be crucial to throwing velocity. Of interest to the authors is whether rotational mobility and power influence throwing velocity among cricketers.

Lack of flexibility in athletes has been related to decrease in performance (21). Therefore, adequate rotational range of motion (ROM) of the hips and the thoracic spine could play a significant role in any throwing activity. Because a sequential pattern of proximal to distal is observed in most throwing and striking sports (17), it is important to identify the influence of rotational mobility throughout the kinetic chain, especially the hips and the thoracic spine which allow the greatest rotation because of the orientation of the joints (20). In this regard, a seated bar in a front rotational test with high reliability (intraclass correlation coefficient [ICC] > 0.80) can be used to provide evidence of thoracic mobility with a goniometer (9). Similarly, a seated hip rotational assessment has also been incorporated successfully (11) and considered highly reliable (ICCs: 0.93 and 0.96; Coefficient of Variation (CV): 12.3 and 8.3%) using an inclinometer (16). However, no researcher to date has investigated the role of hip and thoracic mobility on cricket ball–throwing velocity.

The ability to rapidly produce force in the transverse plane can be considered important in a rotational reliant sport such as cricket. Sports that involve throwing motions can be considered rotational power sports because of the requirement of explosive movements in either the transverse or oblique planes (4). Implements, such as the medicine ball and cable pulleys, can be very useful in developing and quantifying rotational power as they allow motion in all 3 planes. Rivilla-Garcia et al. (18) reported a high correlation ($r = 0.90$) between a light overhead medicine ball throw (0.8 kg) and handball-throwing velocity. Conversely, Kohmura et al. (10) reported that the scoop medicine ball throw had very little shared variance with baseball fielding (throwing distance, standing long jump, and agility T-test) (~7%) compared with batting (~46%). It can be noted that task specificity and weight of the medicine ball may be practically important when quantifying the influence of the medicine ball throw on throwing velocity.

Similarly, the chop and lift can also be considered a rotational power assessment task given the dynamic control required in all 3 planes (2). Rotational power assessments, such as medicine ball throws (side, overhead, scoop) and the chop and lift, have shown high reliability: ICC = 0.84–0.99 (10,12,18) and 0.87–0.98 (15), respectively. There are currently no studies investigating the effect of training using the chop and lift on cricket ball–throwing velocity, and such studies could provide valuable information. In addition, further research regarding the reliability of the chop and lift assessment may be necessary among the athletic population, as previous researchers (15) included nonathletic population to report the interday reliability of chop and lift.

Given the limitations mentioned, the purpose of this article was to investigate the role of upper-body rotational power and thoracic/hip mobility on cricket ball–throwing velocity. It is hypothesized that athletes with greater throwing velocity will demonstrate increased rotational mobility and power capacities. The findings from this study should provide some insight regarding the role of proximal mobility and power transference in a throwing task, such as cricket ball throw. Furthermore, this study may help strength and conditioning specialists develop individualized training programs for cricketers and other rotational sport athletes.

Methods

Experimental Approach to the Problem

The rotational mobility and power of professional and under-19 club-level male cricket players were assessed on one occasion. A linear position transducer (Model PT9510-0150-112-1310; Celesco, Chatsworth, CA, USA) was attached to the weight stack of a cable pulley system (Life Fitness, Chicago, IN, USA) to measure chop and lift power. Seated/standing cricket ball and medicine ball throw velocities were measured using a radar gun (STALKER ATS II, Applied Concepts, Inc.; Texas, USA). Seated active hip and thoracic rotation ROMs were measured using an inclinometer and a goniometer, respectively. Thereafter, participants were divided into 2 groups (fast and slow) based on cricket ball–throwing velocity. The fast group consisted of participants with a throwing velocity greater than 107.3 $km \cdot h^{-1}$, which included 7 professional players and 4 under-19 players. The slow group (i.e., <107.3 $km \cdot h^{-1}$) comprised of 6 under-19 players and 4 professional players. An independent T-test was used to determine between-group differences on the variables of interest.

Subjects

Eleven male professional cricket players (age = 23.8 ± 2.27 years, height = 183 ± 9.83 cm, mass = 88.5 ± 7.25 kg) and 10 under-19 club-level cricketers (age = 17.78 ± 0.44 years, height = 178 ± 8.54 cm, mass = 75.6 ± 11.9 kg, age range: 17–18 years) volunteered to participate in this study. Players reporting any major musculoskeletal injuries, as assessed by the team physiotherapist in the 3 months before the test, were not included. All participants provided written informed consent (parental/guardian consent for participants under the age of 18 years), and the ethics review board of Auckland University of Technology approved the study.

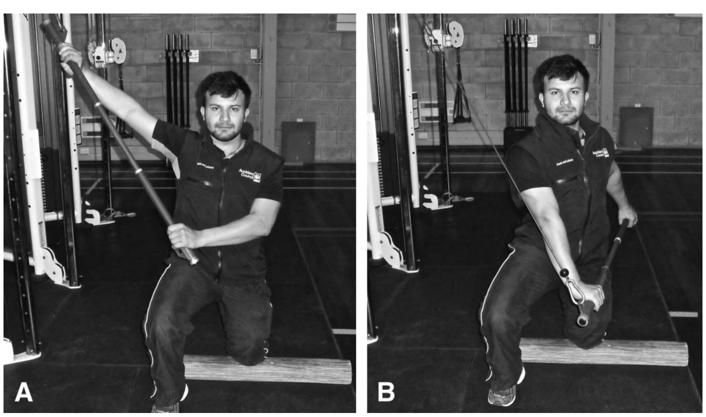

Figure 1. A) Chop start. B) Chop finish.

Procedures

A standardized general warm-up (10 minutes), comprising low- to moderate-intensity exercises involving the hips, trunk, and the upper and lower extremities, was used to prepare the participants for the assessments. Participants were then familiarized with the movements used in this study. Anthropometric measurements were performed followed by standing and seated cricket ball throw, chop and lift, and standing and seated medicine ball throw. The order of the assessments

Figure 2. A) Lift start. B) Lift finish.

was based on neuromuscular requirements and complexity associated within each assessment (13). Participants were provided 2 minutes of rest for all the power-related assessments: cricket and medicine ball seated and standing throws and chop and lift (13).

Assessments

A half-kneeling position (15) was used for the chop and lift assessment in this study. Unlike the study by Palmer and Uhl (15), there was no emphasis on narrow base of support as long as the participants maintained a neutral spine throughout the movement (rear aspect of the head and sacrum in a vertical line). If any participant did not maintain neutral spine during the chop and lift assessment, the attempt was not considered and the participant was asked to retest. A low-density foam roll was used to support the weight-bearing knee for the comfort of the participant (Figures 1A and 2B). The resistance for the chop was 15% of the individual's body weight and 12% for the lift (15). A cable pulley system (Life Fitness) along with micro resistance plates (0.25–5 kg) and a long metal dowel (0.9 kg) was used in the assessment protocol. The height of the cable pulley (i.e., highest for chop and lowest for lift) was same for all the participants regardless of their kneeling height. The chop assessment was performed before the lift. Participants were allowed 2 practice trials each before the test trials for both chop and lift. Furthermore, participants were instructed to provide maximal effort for each test and were tested twice on each side. The end of the entire contraction for both the lifts was considered to be the completion of a repetition, i.e., pull/push phase of both chop and lift. The greater of the 2 attempts with regard to power output was used for analysis.

The overhead cricket ball throw (standing and seated) and side medicine ball throw (standing and seated) were performed on a cricket pitch (20.12 m long). Participants were permitted one stride forward for the standing cricket ball throw while maintaining the front foot behind the line until ball release. Participants were asked to throw the cricket ball into a net with no specific target. The primary objective of this study was to attain maximal throwing velocity, and therefore, no specific targets were set because of speed-accuracy trade-off (6). Outside factors, such as approach speed, approach angle, and ball pick up, were excluded in this study (6).

The side medicine ball throw was performed by grasping the medicine ball (2 kg) with both hands, rotating the trunk opposite to the throwing direction as in a countermovement, followed by rotating the trunk to the throwing direction attempting

Figure 3. A) Side medicine ball start. B) Side medicine ball finish.

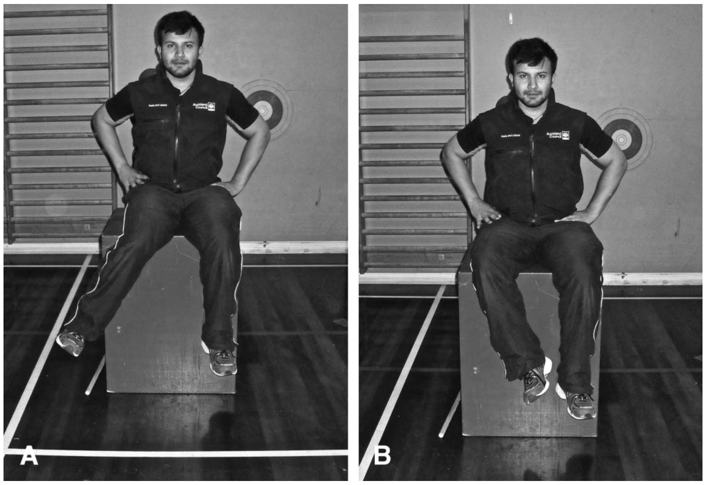

Figure 4. A) Hip internal rotation. B) Hip external rotation.

to throw the medicine ball as fast as possible (7) (Figures 3A, B). Participants were asked to attempt 2 throws for each type (seated/standing cricket and medicine ball throws), and the throw with a greater velocity was used for analysis. The seated cricket and medicine ball throws were performed sitting on a box (30 inches/76.2 cm high) without the feet touching the surface of the floor (to eliminate lower extremity contribution). All the throws (standing and seated) were performed on both sides (i.e., right and left).

The hip rotation ROM was performed on a box (30 inches/76.2 cm high) with the legs resting comfortably off the edge of the box. In a seated position, participants were asked to actively rotate the hips internally and externally while stabilizing the trunk and the hips placing their hands on the hips (Figures 4A, B). The femur was stabilized to limit accessory motion, whereas the lower shank was rotated (internally and externally) until end ROM (11).

Seated thoracic ROM assessment (Figures 5A, B) was performed on a box (30 inches/76.2 cm high) with the hips and knees flexed at 90°, and a ball (20 cm diameter) was placed between the knees to minimize motion of the lower extremities during thoracic rotation (9).

Statistical Analyses

A linear position transducer attached to the weight stack of the cable machine measured vertical displacement relative to the ground with an accuracy of 0.1 cm. Data were collected at a sample rate of 500 Hz by a computer-based data acquisition and analysis program. The displacement-time data were filtered using a low-pass fourth-order Butterworth filter with a cutoff frequency of 50 Hz to obtain position. The filtered position data were then differentiated using the finite-difference technique to determine velocity (v) and acceleration (a) data, which were each successively filtered using a low-pass fourth-order Butterworth filter with a cutoff frequency of 6 Hz (3,22). The force (F) produced was determined by adding the mass of the weight stack to the force required to accelerate the system mass. After these calculations, power (P) was determined by multiplying the force by velocity at each time point ($P = F \times v$). Average power was determined from the averages of the instantaneous values over the entire push-pull phase of chop and lift (until end of movement, i.e., end position). The external validity of the derived measurements from a linear position transducer has been assessed using the force plate as a "gold standard" device (r = 0.78–0.98) (3).

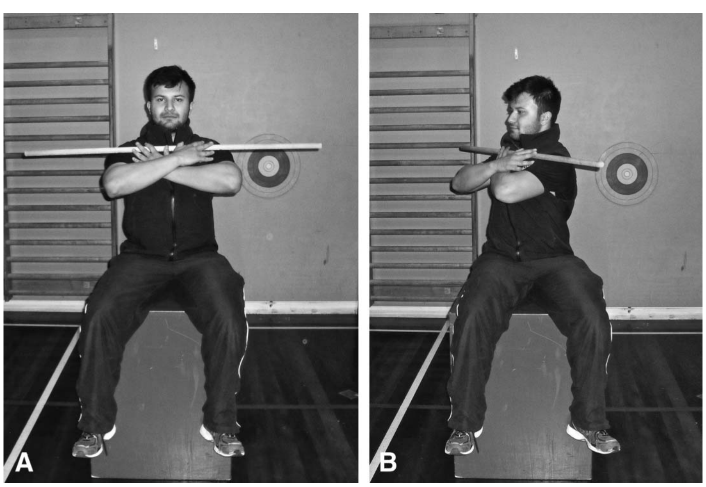

Figure 5. A) Thoracic rotation start. B) Thoracic rotation finish.

The radar gun (STALKER ATS II) was placed behind the participant who was performing the throw to measure the ball release speed (kilometers per

Table 1. Comparison of fast and slow throwers.

Variables	Fast ($X \pm SD$)	Slow ($X \pm SD$)	Mean difference	p
Standing cricket ball (km·h^{-1})	112 ± 4.14	101 ± 5.33	11.03	0.00*
Seated cricket ball (km·h^{-1})	86.6 ± 4.77	75.9 ± 4.27	10.7	0.00*
Mass (kg)	86.7 ± 11.6	77.7 ± 10	8.93	0.07
Height (cm)	183 ± 8.98	177 ± 9.22	6.25	0.13
Arm length (cm)	81.9 ± 5.75	77.7 ± 4.82	4.21	0.09
Leg length (cm)	95.9 ± 7.11	93.8 ± 5.85	2.14	0.46
Seated medicine ball (km·h^{-1})	33 ± 3.70	31.6 ± 2.84	2.21	0.14
Standing medicine ball (km·h^{-1})	39.6 ± 3.70	38.3 ± 2.18	1.33	0.33
Chop force (N)	113 ± 28.6	92.5 ± 16.7	20.8	0.05*
Chop work (J)	102 ± 41	70 ± 20.7	31.8	0.04*
Chop power (W)	419 ± 125	354 ± 64.9	65.2	0.15
Chop velocity (m·s^{-1})	2.15 ± 0.38	2.11 ± 0.21	0.04	0.78
Chop displacement (m)	0.85 ± 0.14	0.82 ± 0.11	0.03	0.55
Lift force (N)	76.52 ± 25	63.8 ± 23.8	12.8	0.25
Lift work (J)	68.4 ± 27.5	57.9 ± 22	10.4	0.35
Lift power (W)	290 ± 92.7	232 ± 101	58.1	0.18
Lift velocity (m·s^{-1})	2.02 ± 0.36	1.82 ± 0.40	0.21	0.22
Lift displacement (m)	0.83 ± 0.14	0.73 ± 0.13	0.11	0.09
Hip internal rotation (°)	33.3 ± 5.08	38.9 ± 7.28	−5.53	0.06
Hip external rotation (°)	41.1 ± 5.86	46.6 ± 5.21	−5.47	0.04*
Thoracic rotation nondominant† (°)	56.6 ± 10.9	68 ± 6.38	−11.4	0.01*
Thoracic rotation (°)	58.2 ± 11.8	67.2 ± 4.37	−9.02	0.03*

*Significantly different between groups.
†Nondominant side.

hour). Newton and McEvoy (14) found the radar gun to be reliable in measuring throwing velocity among baseball players, reporting a strong correlation ($r = 0.95$) between days. In addition, a goniometer (plastic) and a digital inclinometer were used to measure thoracic and hip rotation ROMs, respectively. The goniometer was aligned parallel to the ground at the midpoint between T1 and T2 (thoracic vertebrae) spinous processes, with the spine of the scapula as a reference point. The ROM was then measured with the moving arm of the goniometer while maximally rotating to one side (9). A digital inclinometer measuring angular position/displacement over the full 360° with respect to the vertical axis was used for the hip rotation ROM assessment (11).

Means and *SDs* were used as measures of centrality and spread of data. Participants ($n = 21$) were divided into 2 groups (fast: $n = 11$ and slow: $n = 10$) on the basis of their standing cricket ball–throwing velocity. An independent t-test was used to determine between-group differences. An alpha level of 0.05 was used as the criteria measure for significance. All significant values (differences) for both dominant and nondominant sides are provided in Table 1.

Results

The means, *SD*s, and between-group differences for fast and slow throwers can be observed in Table 1. The fast and slow throwing groups differed by 11.03 km·h^{-1}. The differences observed in seated cricket ball throw between fast and slow throwers were significant (12.3%, $p = 0.00$) and similar in magnitude to standing cricket ball–throwing velocity. The faster throwers were on average 6 cm taller and ~9 kg heavier than their slower counterparts. However, all anthropometric differences were found to be statistically nonsignificant between groups.

The standing medicine ball throw velocity was ~14 to 17% greater than the seated medicine ball throw in fast and slow groups, respectively. Also greater power output (30.8–34.5%) was associated with the chop compared with the lift. Only the chop force (18.4%) and work (31.2%) measures were found to differ significantly between fast and slow throwers.

In terms of the ROM measures, hip external rotation ROM on the dominant side and bilateral thoracic rotational ROM (dominant and nondominant) were found to differ significantly (11.7–16.8%) between groups. However, no significant difference was observed in the hip internal rotation ROM.

Discussion

It was hypothesized that greater rotational ROM at the hip and in the thoracic region, in combination with greater rotational power, would result in increased throwing velocity. Significant differences were noted in thoracic rotation (both sides) and hip external rotation (dominant side). However, it was observed that the faster throwers did not have greater ROM. Furthermore, force and work done during chop on the dominant side were significantly different between fast and slow throwers. No other power variables were found to differ significantly between groups.

In terms of the cricket ball–throwing velocity, the mean peak velocities observed in this study (101–112 $km \cdot h^{-1}$) were very similar to those reported by Freeston et al. (6) among elite (senior) and under-19 cricketers (100.4–109.4 $km \cdot h^{-1}$). The mean peak side medicine ball–throwing velocities of this study (38.3 and 39.6 $km \cdot h^{-1}$) were very similar to those reported by Ikeda et al. (8) among competitive throwers and baseball players (36.5 and 41.4 $km \cdot h^{-1}$) using a similar weighted medicine ball (2 kg). However, the differences in medicine ball–throwing velocity (seated and standing) between the fast and the slow groups were nonsignificant in this study. Nonetheless, it would seem that the throwing abilities of the participants used in this study were typical of other athletic populations.

With respect to thoracic and hip rotation ROMs, the mean seated bar in front position for the thoracic rotation ROM was found to be greater (56.6–68°) in this study compared with those reported (53.7–57.6°) by Johnson et al. (9). Furthermore, active hip internal and external rotation ROMs on the dominant side were also found to be greater in this study (internal rotation: 33.3–38.9° and external rotation: 41.1–46.6°) compared with those reported by Ellenbecker et al. (5) (internal rotation: 23° and external rotation: 34°) among professional baseball players. The differences observed in the hip rotation ROM values between both the studies could be sport specific or most likely be attributed to methodological dissimilarities between studies, e.g., seated in this study vs. prone in the study by Ellenbecker et al. (5).

In this study, significant differences were observed in active hip external rotation on dominant side and bilateral (both sides) thoracic rotation ROM between fast and slow throwers. However, the faster throwers in this study had decreased ROM compared with their slower counterparts. These findings are similar to the study by Robb et al. (19) that reported moderate correlation ($r = 0.50$, $p < 0.04$) between lower total hip rotation arc passive ROM on the nondominant side and throwing velocity among professional baseball pitchers. Excessive rotation at the hips can put the pelvis and foot in a more open position, thereby prematurely initiating the arm cocking phase and resulting in loss of kinetic energy in the lower extremity (19).

In terms of power output, the athletes of this study produced slightly higher peak power outputs (chop: 354–419 W; lift: 232–290 W) to those reported by Palmer and Uhl (15) for the nonathletic population in their study (chop: 346–395 W; lift: 181–223 W). Significant differences were observed between fast and slow throwers regarding the chop (work and force) but not for the lift. These differences may be attributed to throwers being heavier and taller, and therefore, the relative masses and the distance that the load is moved are greater for this population. However, the intergroup differences in the other measure of rotational power (seated medicine ball throws) were found to be statistically nonsignificant.

Practical Applications

Greater ROM of the hip and thoracic region was not associated with greater throwing velocity. Therefore, strength and conditioning professionals should be careful in promoting excessive ROM in the proximal segments, as excessive ROM might be detrimental in transferring optimum power through the kinetic chain in an explosive task such as throwing. However, adequate ROM may be necessary to effectively carry out a throwing task because of the sequential pattern of proximal to distal linkage.

Rotational power as measured in this study may not be an important contributor to throwing velocity in cricket. Understanding the rotational contribution is further complicated by the intergroup anthropometric differences. The implications of these findings are as follows: (a) better measures/tests are needed to clarify the contribution of rotational power that control for anthropometric factors and/or (b) rotational power may not be important but rather having a relatively stiff trunk that transfers the momentum generated in the lower body to the distal segments without energy leakage may be more important. The ROM results would certainly support such a contention, those with reduced ROM at the hip and in the thoracic region producing greater throwing velocity.

In addition, significant differences were observed in this study with regard to seated cricket ball–throwing velocity among fast and slower throwers, suggesting the importance of the upper extremity particularly the distal segment. A seated throwing position can reduce the involvement of proximal segments (trunk and legs) requiring greater contribution from the distal segments, such as the arms and hands. Therefore, future research should include assessments that quantify the contribution of the distal and proximal segments with regard to ROM and power output.

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