THE EFFECTS OF DEEP SQUAT "ROM" ON BASEBALL THROWING DYNAMICS OF LOWER EXTREMITIES OF POSITION PLAYERS

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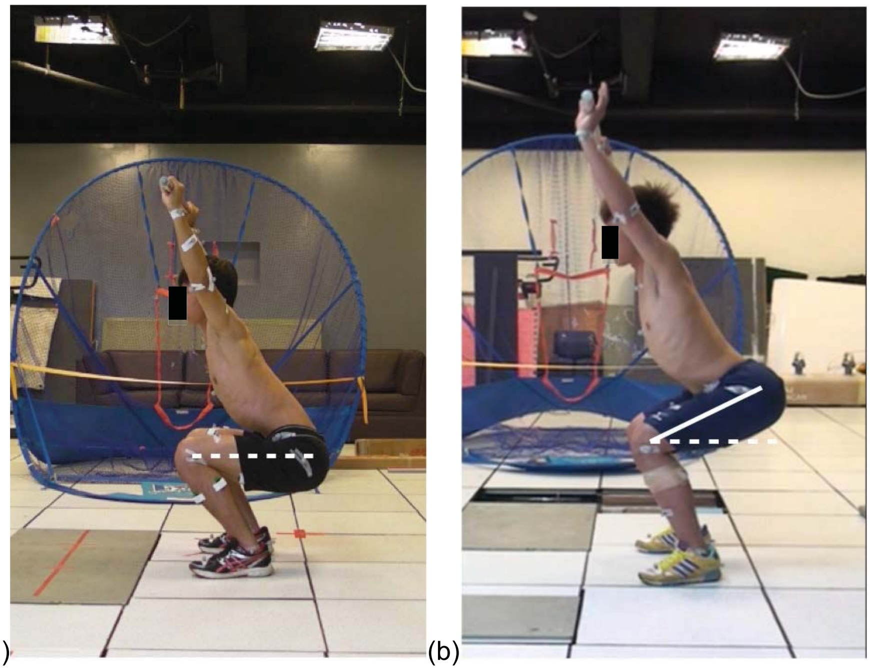
We investigated the differences in peak ground reaction force of the stride and the pivot foot of baseball throwing between the different FMS^{TM} scoring groups. Thirteen collegiate baseball position players were divided into two groups, LS (femur below horizontal) and HS (femur above horizontal) adopting the FMS^{TM} "deep squat" screen. During the throwing test, the players completed five throws with maximal effort towards a target. A speed gun and force plates were utilized to measure ball speed and ground reaction force. There was no significant difference in ball speed between the two groups; however, peak vertical reaction force of stride foot was significantly higher in LS group.

KEY WORDS: kinetic chain, ground reaction force, compensatory movement

INTRODUCTION: Throwing ability is one of the most important skills in baseball. Players must be able to throw a ball after catching in a relatively short period of time. This requires good coordination in the lower extremities. Macwilliams, Choi, Perezous, Chao, and McFarland (1998) suggested that over-shoulder throwing requires good coordination of the joints, with the lower limb joints providing the strength vital in initializing the throw. However, throwing is a unilateral movement and long-term extensive training in throwing can lead to asymmetries in the human body that may potentially hinder performance. The Functional Movement Screen (FMS^{TM}) can be used to assess dysfunctions of the body, including range of motion, stability, and compensatory patterns (Cook, Burton, and Hoogenboom, 2006) and has been widely used to screen athletes in recent years. The "deep squat" screen, within the total of 7 FMS movements, can reflect the overall FMS scores well and plays a representative role in FMS (Kiesel, Plisky and Butler, 2011). The ability to reach below parallel in the deep squat represents good coordination of joints (hip, knee, and ankle) and dynamic chain (Kiesel, Plisky and Voight 2007). In the past, baseball related research had not been focused on throws of the position players, nor on functional movement qualities of the lower extremities; however, the throwing movement must be initialized by the lower limbs, and it is natural to assume range of motions in the hip, knee and ankle joints may also affect performance and skill characteristics. Hence, we use the FMS^{TM} "deep squat" as a tool to assess subjects and to investigate whether the quality of the squat can influence throwing performance (ball velocity) and skill characteristics. If the links can be made, an athlete's limitations might be recognized for potential improvements.

METHODS: Thirteen college male baseball position players volunteered as participants. All participants provided written informed consent to participate in the study after being informed of its purpose and associated risks. This study was approved by the Institutional Review Board of Fu Jen Catholic University. Before the warm-up, we performed the FMS^{TM} "deep squat" screening test (Figure 1) and based our differentiation of LS (hip joint centre below knee joint centre, 7 players) and HS (hip centre above knee centre, 6 players) squat types upon the original FMS scoring criteria by Cook et al. (2006). After warm up as personal routine, the participants were asked to throw 5 times with maximal effort, and the fastest throw was recorded for analysis. Due to spatial limitations, the distance between the subject and the target zone was set to be 8 meters. The JUGS Sport speed gun was used to measure ball release velocity, and the Eagle System with 8 infrared cameras (250Hz) were used to measure the pitching phases. Two AMTI force plates were set up at 1000Hz sampling rate to collect the GRF data and verify the instant of stride foot contact the ground. Kinematic data were smoothed using fourth order Butterworth low-pass filter with a cut-off frequency set at 18Hz. According to suggestions by Escamilla, Fleisig, Barrentine, Zheng, & Andrews (1996), the stride phase and arm cocking/acceleration phase were determined, while peak GRF of the pivot leg during stride phase and the GRF of the stride leg during arm cocking/acceleration phase were recorded. Statistical analysis between LS and HS groups were performed using the SPSS software. The independent *t*-test was performed to investigate differences in height, body weight, baseball carrier, ball velocity, and peak GRF for the stride leg and pivot leg between the two groups.



(a) (b)

Figure 1: The deep squat of a typical LS (a) and HS (b)

RESULTS and DISCUSSION: The present research compared the differences of the pitching performance and ground reaction force between the LS and HS groups that separated by the performing of the FMS deep squat. Due to less bilateral joint restrictions, participants in the LS group were able to perform deeper squatting range of motion than the HS group without compensation. The comparison of anthropometric parameters and performance between LS and HS groups is showed in Table 1. No significant differences between the groups in either height, body mass, baseball carrier, or ball velocity is presented. Peak stride-leg GRF of the LS group was proved to be significantly higher than that of the HS group (table 2). Ground reaction force on the stride leg has been shown to translate the forward momentum provided by the pivot leg into trunk rotation (MacWilliams et al., 1998). The HS group need to produce larger vertical GRF of stride leg to brake the body and translate the momentum upward because that they don’t have good hip mobility. If the joint function of the lower limb is compromised, it might hinder this part of kinetic chain and in turn, lessen the conversion of momentum from lower limbs towards the upper body. Less momentum transfer of this sort may add on to the stress on the pitching arm (Kibler, and Chandler, 1995). Thus, with the same pitching velocity, higher efficiency of transfer of energy in the LS group may further lessen the stress on the pitching arm, potentially lowering the risk of further injury.

Table 1
Data of Participants

Variables	LS Group (N=7)	HS Group (N=6)	p Value
Body Height (m)	1.77±0.06	1.80±0.09	.449

Body Mass (kg)	87.86±16.27	86.67±21.96	.913
Baseball Career (years)	12.14±1.86	9.67±3.20	.110
Ball velocity (km/h)	103.43±11.92	107.83±9.86	.488

*:p<.05

Table 2
Comparison of stride and pivot leg peak GRF parameters between LS and HS

Variables (unit: BW%)	LS Group (N=7)	HS Group (N=6)	p Value
Pivot Leg GRF-Throwing Direction	36.76±3.35	40.73±10.81	.374
Pivot Leg GRF-Left Direction	2.59±4.06	2.78±1.74	.919
Pivot Leg GRF-Right Direction	-6.38±7.26	-8.05±4.98	.634
Pivot Leg GRF-Vertical Direction	117.78±4.45	121.35±13.69	.564
Stride Leg GRF-Throwing Direction	-58.50±7.65	-66.34±13.65	.218
Stride Leg GRF-Left Direction	22.40±20.17	23.80±6.56	.874
Stride Leg GRF-Right Direction	-10.27±11.41	-9.99±5.59	.956
Stride Leg GRF-Vertical Direction	147.04±17.95	195.53±41.00	.016*

*:p<.05

CONCLUSION: In the present study we discovered some difference in the deep squat that may leads to different kinetic properties during the pitching motion. The HS group produce larger vertical GRF of stride leg to brake the body and translate the momentum upward, and with higher mobility presented by the LS group may come higher efficiency in energy transfer, potentially lowering the loading of the upper limb. Further research on this topic on pitchers is needed in order to investigate training implications.

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