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EFFECT OF UPPER LIMB ON GROUND REACTION FORCES DURING SINGLE-LEG JUMP STOP LANDING TASK

Atipong MONGKOLPICHAYARUK[1], Bavornrat VANADURONGWAN[2], Parunchaya JAMKRAJANG[1], Weerawat LIMROONGREUNGRAT[1]

[1]College of Sports Science and Technology, Mahidol University, Thailand 73170
[2]The Department of Orthopaedic Surgery, Faculty of Medicine Siriraj Hospital, Mahidol University, Nakhon Phathom, Thailand 73170

ABSTRACT

Blocking shot is one of the defensive basketball skills where a player raises an arm to block or intercept a shot. To block a shot, a player usually jumps and lands on one leg. Previous study investigated ground reaction forces (GRF) during drop vertical jump. However, there is no previous study that has investigated the effect of single arm motion on GRFs during single-leg landing (SLL). Therefore, the purpose of the study was to investigate and compare the effect of dominant and non-dominant arm raise on GRFs during SLL. Five female basketball players ($\bar{x}_{age}$ = 20.40 ± 0.44 years old, $\bar{x}_{weight}$= 64.80 ± 7.71 kg and $\bar{x}_{height}$= 1.71 ± 0.03 m) participated in this study. Participants performed single-leg landing (SLL) onto a force platform on 4 conditions; 1) non-dominant arm raise landing by non-dominant leg (NDA-NDL), 2) non-dominant arm raise landing by dominant leg (NDA-DL) 3) dominant-arm raise landing by dominant-leg (DA-DL) and 4) dominant-arm raise landing by non-dominant leg (DA-NDL). The vertical GRF at maximum results showed significant differences between NDA-NDL vs. DA-DL and NDA-NDL vs, DA-NDL. Whilst, the peak posterior GRF results show no significant difference between 4 conditions. This study shows that non-dominant arm raise has an effect on ground reaction forces. Therefore, researchers suggest that basketball players should practice to improve the use of a non-dominant arm when landing after performing blocking shot for alternatively defense action.

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Key Words: Basketball, Dominant/non-dominant leg, Ground reaction force, Landing.

*Corresponding author: Weerawat LIMROONGREUNGRAT
College of Sports Science and Technology
Mahidol University, Nakhon Pathom, Thailand 73170
E-mail: weerawat.lim@mahidol.edu

INTRODUCTION

Basketball is one of the most popular sports in the world. Basketball players must possess various skills including dribbling, shooting and blocking. Blocking is one of the defensive skills where a basketball player raises their arm to block or interfere a shot. A defensive player often runs and jumps toward a shooter and lands on the ground with one leg.

Kinematics and kinetics of single-leg landing (SLL) have been investigated and compared to double-leg jump landing in basketball and other sports [1, 2]. Wang[1] (2011) reported that SLL was significantly larger ground reaction force (GRF) and increase knee tibia shear force during landing than double leg landing. Moreover, knee and hip flexion angles decreased at initial contact. Cowley et al[2] (2006) reported basketball athletes had greater GRFs and decreased stance time during the drop vertical jump. Additionally, they found that football and basketball players had greater valgus angles in the dominant and non-dominant limb during performing cutting side than drop vertical jump.

Upper limbs motion have previously shown that they can influence biomechanics of lower extremity[3 4]. For example, when a player blocks a shot, they raise an arm and then jump to defend the oppositions attempt to score, therefore due to CG (center of gravity) their position shifted during landing. Masters et al[3] (2016) reported that there was a significant decrease degree of maximum hip flexion and a significant increase in peak dorsiflexion during drop-landing when arms held a ball away from the body. Chaudhari et al[4] (2005), on the other hand, studied the effect of holding the sport equipment on biomechanics of the knee joint during side cutting. The result showed that holding the sport equipment significantly increased knee valgus moment during cutting task. According to the previous findings, it is more likely that upper limb movement could affect the biomechanics of jump landing particularly during SLL. However, no previous study has investigated this effect of single arm motion on GRFs during SLL. Therefore, the purpose of this study was to investigate and compare the effect of dominant and non-dominant arm on GRFs during SLL. We hypothesized that there would be differences of the GRFs between ipsilateral and contralateral of arm and leg during SLL.

METHODS

Five female basketball players ($\bar{x}_{age}$ = 20.4 ± 0.44 years old, $\bar{x}_{weight}$ = 64.8 ± 7.71 kg and $\bar{x}_{height}$ 1.71 ± 0.03 m) volunteered in this study. All participants had a minimum of one-year experience in basketball competition and trained regularly at least 3 times per week. Subjects were excluded if they had 1) history of ACL injury or lower extremity injury in the past 6 months, 2) Q angle greater than 20º and 3) Navicular drop test more than 10 mm. All participants signed a written informed consent approved by the Human Research Protection Unit, Siriraj hospital, Mahidol University (221/2561(EC1)).

Participants were asked to warm-up for 10 minutes including general warm-up for 5 minutes and lower limb dynamic stretching 5 minutes (body weight squats, rotational lunges, side lunges, hamstring walks)[3].

Handgrip strength measurement was used to determine a dominant arm and non-dominant arm. The arm that has the highest score is considered as a dominant arm (DA)[5]. To determine dominant and non-dominant leg, single hop distance (distance from the toe at the starting point to the heel at landing) of each leg was performed.[6,7] Dominant leg (DL) was the leg that has the greatest hop distance. The jump target is set at the target height of approximately 80 percentage of maximal vertical jump and the jump distance is approximately 80 percentage of maximal single hop distance.

EXPERIMENT PROCEDURE

Prior to the test, all participants performed maximum vertical jump test. All participants then were asked to perform a maximal forward jump to a target with both legs while reaching the arm as high as possible, similar to blocking motion in a basketball game. All participants landed on one leg onto a force platform (BP400600 AMTI Inc., MA) which registered GRFs at the sampling rate of 1600 Hz. This experimental procedure was modified from Orishimo et al,[6] Nin et al[8] and Rosen et al.[9]

Four SLL conditions were performed 1) non-dominant arm raise landing by non-dominant leg (NDA-NDL), 2) non-dominant arm raise landing by dominant leg (NDA-DL) 3) dominant-arm raise landing by dominant-leg (DA-DL) and 4) dominant-arm raise landing by non-dominant leg (DA-NDL). The order of the test was randomly assigned. Three successful trials per each condition were performed. A successful trial has been identified by a participant that can maintain a balance on the force platform after forwarding jump landing. One-minute rest between each trial and 2-minute rest between each condition were allowed. Visual 3D software (C-motion Inc., USA) was used to filter raw GRF data with low-pass Butterworth cutoff frequency at 20 Hz. Vertical and posterior GRFs at the two events, 1) at maximum GRF and 2) at maximum knee flexion, were obtained. Data from the three trials was averaged and analyzed. All GRF data was normalized by subjects' body weight (BW).

Statistical analysis

All statistical analysis was performed using SPSS (Version 20.0). Kolmogorov-Smirnov test revealed normality of data. Thus, repeated measures ANOVA were used to determine differences of GRF between 4 conditions. Pairwise comparison was used for post-hoc analysis if there were significant differences. The significance level was set at p-value < 0.05.

RESULTS

Mean and standard deviations of GRF data in both vertical and anteroposterior directions of all conditions are showed in Table 1. Repeated measure ANOVA revealed only differences of maximum vGRF (Figure 1). Post-hoc analysis showed differences between NDA-NDL vs DA-DL and NDA-NDL vs DA-NDL.

However, No significant differences when examining the VGRF at maximum knee flexion between 4 conditions were observed.

Table 1 Means and SD of GRFs in vertical and posterior direction in all 4 testing conditions.

	NDA-NDL		NDA-DL		DA-DL		DA-NDL	
	N Mean±SD	%BW Mean±SD	N Mean±SD	%BW Mean±SD	N Mean±SD	%BW Mean±SD	N Mean±SD	%BW Mean±SD
Vertical GRF								
At maximum	2255.87±30	3.56±0.69	2297.16±40	3.6 ±0.75	2167.45±30	3.4±0.64	2229.23±42	3.28±0.61
At max knee flexion	986.12±230	1.55±0.41	997.80±234	1.57±0.44	967.83±175	1.52±0.36	937.14±18	1.48±0.4
Posterior GRF								
At maximum	309.18±68.2	0.47±0.08	301.05±72.2	0.45±0.08	305.1±36.38	0.47±0.04	312.8±75.6	0.48±0.07
At max knee flexion	124.95±62.2	0.19±0.1	92.134±51.4	0.15±0.1	138.9±21.5	0.218±0.06	127.5±40.6	0.20±0.07

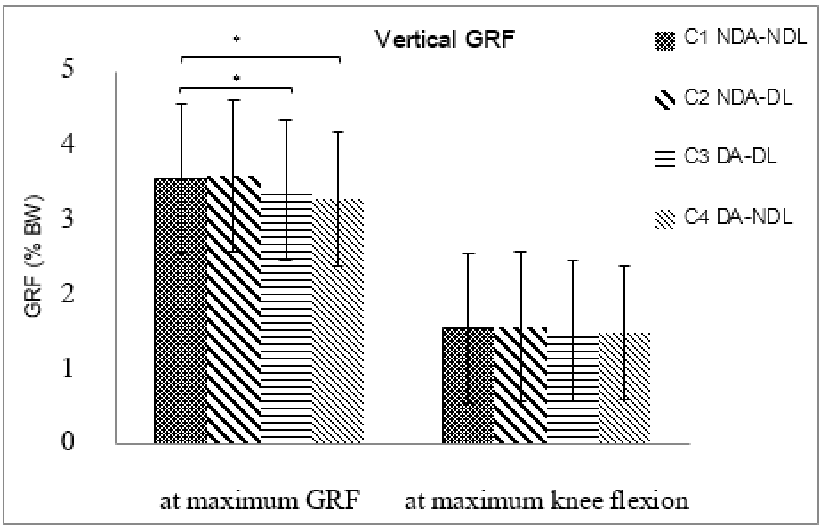

Figure 1 Comparison of the peak vertical GRF and the vertical GRF at maximum knee flexion between 4 conditions. * significant difference at p-value <0.05.

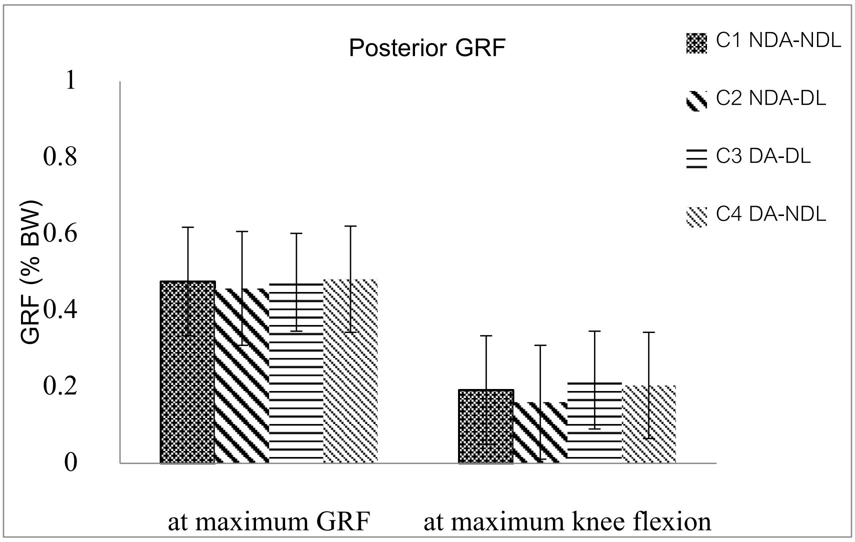

Figure 2 Comparison of the peak posterior GRF and the posterior GRF at maximum knee flexion between 4 conditions.

The maximum posterior GRF results show that there was no significant differences between conditions as well as no significant differences when examining the posterior GRF at maximum knee flexion between 4 conditions were found (Figure 2).

DISCUSSION

The objective of this study was to investigate the effects of upper arm on GRFs during SLL. Upper extremity movement plays an important role in many sports especially, basketball, volleyball and netball[8]. The motion in this study simulates basketball blocking motion, which most players jump toward an opponent and then commonly land on one leg. We also examined how GRFs would change if players land on their dominant leg or non-dominant leg when they raise one arm (either dominant or non-dominant arm) to block a shot. Our results showed that there are statistically significant differences of maximum vertical GRF between some conditions. GRFs during SLL have been previously investigated in many sports such as sepaktakraw[10]. The peak VGRF results are similar to previous studies[10 11, 12]. However, only Cowling and colleague (2001)[11] reported VGRF and PGRF during SLL with arms motion to receive a netball. No significant differences of posterior GRF among these conditions were observed.

According to results of the present study, landing with non-dominant arm whether landing on dominant leg or non-dominant leg exhibits greater vertical GRF as compared to landing with dominant arm. This may be because these players are unfamiliar with non-dominant arm motion for blocking shot. These results also imply that upper arm position effects GRFs. No significant differences of both GRF in both vertical and anteroposterior direction at maximum knee flexion were found, which might indicate that these players know how to land on the ground softly. Peak posterior GRF in this study was approximately 0.48 BW. In the previous study, Boyi Dai and colleagues (2015) [13] found peak posterior GRF during side cutting to be 0.67 BW. The discrepancy of results may be due to different activities. In the previous study, participants were asked to run and perform side cutting while participants in this study performed standing jump and land on the force platform. In addition, the previous study[14] presented no significant differences of peak posterior GRF during SLL using either dominant or non-dominant leg which is similar to the present study. The kinetic chain could be used to explain the force transferring strategy when the player jumps as well as moving an arm when performing blocking shot as there is force transfer from ground through segmental joints when generating force during jumping. The novel approach introduced in this study, and the key outcomes of the work, have the potential to give researchers, coaches and athletes an opportunity to better understand the effects of upper arm on GRFs during single leg landing on dominant or non-dominant side. Furthermore, training on both sides of the body (dominant or non-dominant side) may help to improve performance and reduce potential injury.

CONCLUSION

Our findings show that non-dominant arm raise has an effect on GRFs during SLL in the pattern of basketball block shot. However, these results show that the volume of the GRF is high, which may be due to a reduction in stability when landing, as well as landing with the arms raised. This may be caused by the body's center of mass location shifting particularly when moving non-dominant arm. No significant differences between the motion of dominant and non-dominant arm during single-leg by dominant leg landing may be because of the player's skill, prior experiences, and individual technique of landing that influence to landing in each condition. Researchers suggest that basketball players should beware when landing after using non-dominant arm blocking shot as they may use soft landing to reduce high GRFS. Moreover, players should practice to improve the use of a non-dominant arm when landing after performing blocking shot for alternatively defense action.

Limitation and future study

The GRF data was high when performing a SLL with arm motion. Hence, the researcher should be careful when asking the player to perform a SLL to avoid an injury risk. Furthermore, all participants who participated in this study were well trained. This study has been done in a controlled laboratory environment, therefore results may vary compared to a real game environment. Further research is required to confirm whether the motion of arm during landing may influence the magnitude of the ground reaction force in other sports movement and the studies about lower extremity muscle activities in this motion may help to explain the mechanism that decreases the GRF. As this research was conducted with only a small number of subjects, these are preliminary results. A larger sample size is warranted for any future study.

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