THE EFFECT OF REACHING TO AN OVERHEAD GOAL WHILE PERFORMING THE COUNTERMOVEMENT JUMP

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One potentially simple way to maximize jumping effort and thus intensity is to have athletes jump to and attempt to touch challenging overhead goals during training. The purpose of this study was to compare the effect of jumping with and without the use of an overhead goal. Subjects performed 3 countermovement jumps in conditions with and without an overhead goal. Jump performance was evaluated using a force platform to determine peak ground reaction force, time to takeoff, power, and jump height. Data were evaluated with a two way ANOVA with results demonstrating no significant ($p > 0.05$) difference between goal conditions for any of the variables assessed and no interaction between goal condition and gender ($p > 0.05$).

KEYWORDS: plyometrics, effort, intensity, external focus

INTRODUCTION: Research has evaluated the intensity of plyometric exercises indicating that exercise intensity is an important program design variable (Ebben et al., 2008; Jensen & Ebben, 2007). In an attempt to optimize plyometric training intensity, studies have examined internal and external focusing strategies including the use of overhead goals in an effort to examine their effect on jumping performance (Edwards et al., 2008; Ford et al., 2005; Tod et al., 2009; Wulf et al., 2007; Wulf & Dufek, 2009).

Parameters of vertical jump performance including center of mass displacement, impulse, and joint angular velocity have been improved through the use of self talk or exogenous instruction, compared to control conditions (Edwards et al., 2008; Tod et al., 2009), without any reported change in jump height.

Studies evaluating the use of an overhead goal such as jumping to a suspended ball demonstrate slightly higher jumps of approximately 2.2% when compared to a condition without the overhead goal. However, this difference was present only for men without any significant differences for women (Ford et al., 2005). The men in this study accrued this advantage without any difference in jumping biomechanics between the conditions (Ford et al., 2005). When a Vertec (Vertec 2, Sports Imports, Columbus OH) jump height measurement device was used as an overhead focus point, subjects produced higher center of mass displacement, impulse, and joint angular velocities compared to test conditions of using the fingers as focusing strategy (Wulf, et al.,2007; Wulf & Dufek, 2009). Numerical data are limited and the effect of using the Vertec as an external focusing strategy is only compared to the internal strategy of focusing on the fingers while jumping to touch the vanes of the Vertec in some cases (Wulf & Dufek, 2009). Thus, it is unclear how jumping to an overhead goal of the Vertec would differ from a condition of no overhead goal at all. In applied strength and conditioning settings, frequently athletes perform plyometric exercises without any use of an overhead goal. The purpose of this study was to compare the effect of performing the countermovement jump with and without the use of an overhead goal by evaluating subject peak vertical takeoff ground reaction force (GRF), time to takeoff (TTT), power (P), and jump height (JH).

METHODS: Twenty one current or former NCAA Division I and Division II athletes (15 men mean ± SD; age = 22.9 ± 5.9 years, height = 180.0 ± 8.0 cm; body mass = 85.58 ± 9.06 kg) and 6 women; mean ± SD; age = 21.2 ± 1.5 years, height = 168.05 ± 7.9 cm; body mass = 66.27 ± 6.8 kg) served as subjects. All subjects performed a habituation and testing session. Prior to testing, the subjects warmed-up and performed dynamic stretching and jumping exercises. During habituation, subjects were given instruction, a demonstration, and practiced the correct performance of the countermovement jump with and without the Vertec as an overhead goal. During this time, the countermovement jump height was assessed so this value could be used during the test for the overhead goal condition. During testing, subjects performed 6 repetitions of the bilateral countermovement jump with 3 repetitions each alternating repetition by repetition between the jumping to overhead goal and the non-overhead goal conditions. The initial starting order was counterbalanced between subjects. Subjects were allowed to rest 1 minute between test repetitions.

The test exercises were assessed with a force platform (BP6001200, Advanced Mechanical Technologies Incorporated, Watertown, MA, USA) which was calibrated with known loads to the voltage recorded prior to the testing session. Kinetic data were collected at 1000 Hz, real time displayed and saved with the use of computer software (BioAnalysis 3.1, Advanced Mechanical Technologies, Incorporated, Watertown, MA USA) for later analysis. All values were averaged for three trials for each plyometric exercise.

Peak vertical GRF during takeoff, TTT, P, and JH were calculated from the force time records consistent with methods previously used (Canavan & Vescovi 2004; Jensen & Ebben 2007; Moir 2008; Raynor & Seng 1997; Tsarouches et al., 1995, Van Soest et al., 1985). Peak GRF was defined as the highest value attained from the force time record for the take off phase of each jump. Time to takeoff was defined as the time of the point of onset of the flight phase minus the point of onset of the eccentric phase from the force time record. The point of onset of the eccentric phase was identified consistent based on methods previously demonstrated by Jensen et al. (2009). Jump height and power were calculated based in part on flight time using previously published equations (Moir, 2008).

The statistical analyses were undertaken with SPSS 17.0 using the average of the three repetitions of the test countermovement jumps. A two way mixed ANOVA was used to evaluate the main effects for overhead goal condition and the interaction between overhead goal condition and gender for GRF, TTT, P, and JH. The trial to trial reliability of each dependent variable was assessed for each overhead goal condition using average measures intraclass correlation coefficient (ICC). In addition, a repeated measures ANOVA was used to confirm that there was no significant difference ($P > 0.05$) between three trials of each overhead goal condition. An *a priori* alpha level of $P \leq 0.05$ was used.

RESULTS: There was no significant main effects for jump condition for GRF ($p = 0.22$), TTT ($p = 0.17$), P ($p = 0.70$) or JH ($p = 0.70$). There was no significant interaction of jump condition and gender for GRF (p= 0.39), TTT ($p = 0.98$), P ($p = 0.80$) or JH ($p = 0.79$). Trial to trial reliability of all measures in both the overhead goal and no-overhead goal conditions were highly reliable as demonstrated by ICC values of .96 to .99 with no significant differences between trials ($p > 0.05$). Data are presented in Table 1.

Table 1. Mean ± SD ground reaction forces (GRF), time to takeoff (TTT), power (P), and jump height (JH) in overhead and non overhead goal conditions for men and women

	Men (N=15)		Women (N=6)	
	Goal	No Goal	Goal	No Goal
GRF (N)	1383.14 ± 256.12	1349.15 ± 259.89	807.88 ± 95.28	802.58 ± 106.19
TTT (s)	0.62 ± 0.19	0.64 ± 0.16	0.61 ± 0.07	0.62 ± 0.16
P (w)	4379.69 ± 557.19	4382.95 ± 505.27	2862.14 ± 475.12	2879.82 ± 456.13
JH (m)	0.44 ± 0.07	0.44 ± 0.06	0.32 ± 0.06	0.32 ± 0.06

DISCUSSION: This study demonstrates no significant difference between jumping to an overhead goal versus not jumping to an overhead goal for both men or women. This finding was not consistent with the previous findings of small performance differences between overhead goal and no overhead goal conditions (Ford et al., 2005; Wulf et al., 2007; Wulf & Dufek, 2009) and results are similar to the absence of any gender differences in jumping to overhead goals as previously demonstrated (Ford et al., 2005).

Studies have also conceptualized this process of training with overhead goals based in the nature of the focusing strategy including an external focus on the overhead goal and an internal focus on the fingers that touch the goal. In some cases, higher performances when using an external focus compared to the internal focus condition was not compared to a non-overhead goal condition so it makes interpretation of the benefits of an overhead goal difficult to assess (Wulf & Dufek, 2009).

Subject training status and experience with plyometric exercises may affect the potential value of an external overhead goal. In the present study, experienced and well trained subjects may have been more able to give high quality effort without an external goal whereas those who are less experienced or motivated may perform better with the use of the goal. Unfortunately, previous studies do not provide measures of their subjects training status. One study reported using “Division I” soccer players who jumped and grabbed a suspended ball placed overhead. However, presumably soccer players are not experienced with this type of athletic movement since grabbing the ball is against the rules of the sport. Therefore, this is an atypical movement for these athletes and may add a confounding variable to this test (Ford et al., 2005).

CONCLUSION: Performing plyometric exercises with maximal effort it likely to be important along with the progression of exercise intensity. However, based on the kinetic variables assessed in this study the use of overhead goals neither improves nor impairs maximum jumping in fairly well trained subjects.

REFERENCES:

Canavan, P.K., & Vescovi, J.D. (2004). Evaluation of power prediction equations: peak vertical jumping power in women. *Medicine and Science in Sports and Exercise.* 36,1589-93.

Ebben, W.P., Simenz, C., & Jensen, R.L. (2008). Evaluation of plyometric intensity using electromyography. *Journal of Strength and Conditioning Research.* 22, 861-8.

Edwards, C., Tod, D., McGuigan, M. (2008). Self talk influences vertical jump performance and kinematics in male union rugby players. *Journal of Sports Sciences*. 26, 1459-1465.

Ford, K.F., Myer, G.D., Smith, R.L., Byrnes, R.N., Dopirak, S.E., & Hewett, T.E. (2005). Use of an overhead goal alters vertical jump performance and biomechanics. *Journal of Strength and Conditioning Research.* 19, 394-399.

Jensen, R.L., & Ebben, W.P. (2007). Quantifying plyometric intensity via rate of force development, knee joint and ground reaction forces. *Journal of Strength and Conditioning Research*. 21,763-7.

Jensen, R.L., Leissring, S.K., Garceau, L.R., Petushek, E.J., & Ebben, W.P. (2009). Quantifying the onset of the concentric phase of the force–time record during jumping. Harrison AJ, Anderson R, Kenny I, editors. In: *XXVII Congress of the International Society of Biomechanics in Sports*. 2009.

Moir, G. (2008). Three different methods of calculating vertical jump from force platform data in men and women. *Measurements in Physical Education and Exercise Science.* 12, 207-18.

National Strength and Conditioning Association Position Statement (1993). Explosive/Plyometric Exercises. *Strength and Conditioning Journal,* 15, 16.

Raynor, A.J., & Seng, T.Y. (1997). Kinetic analysis of the drop jump: the effect of drop height. In: Walkusji JJ, editors. *AIESEP Singapore 1997 World Conference on Teaching, Coaching and Fitness Needs in Physical Education and the Sports Science Proceedings.* Singapore: p. 480-6.

Tod, D.A., Thatcher, R., MuGuigan, M. & Thatcher, J. (2009). Effects of instructional and motivational self talk on the vertical jump. *Journal of Strength and Conditioning Research*. 23, 196-202.

Tsarouchas L, Giavroglou A, Kalamaras K, & Prassas S. (1995). The variability of vertical ground reaction forces during unloaded and loaded drop jumping. In: *Biomechanics in Sports: 12th symposium of the International Society of Biomechanics in Sports.* Budapest: International Society of Biomechanics in Sports; p. 311-4.
Van Soest, A.J., Roebroeck, M.E., Bobbert, M.E., Huijing, M.F., Van Ingen, P.A., & Schenau, G.J. (1985). A comparison of one-legged and two-legged counter-movement jumps. *Medicien and Science in Sports and Exercise*. 17, 635-9.
Wulf, G, Granados, C., & Dufek, J. (2007). Increases in jump and reach height through an external focus. *Journal of Sport and Exercise Psychology*. 29, s 141.
Wulf, G., & Dufek, J.S. (2009). Increased jump height with an external focus due to enhanced lower extremity joint kinetics. *Journal of Motor Behavior*. 41, 401-409.

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