THE COMPARISON OF WORK INTENSITY AND EXERCISE PERFORMANCE BETWEEN SHORT-STRETCH AND LONG-STRETCH DROP JUMP

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This experiment is to investigate the kinematic and dynamic variables of drop jumps (DJ) in order to understand the differences on force and sport performance between two different stretch amplitudes of SSC movements. The short-stretch DJ and long-stretch DJ were performed by 11 subjects of jumpers and sprinters with average ages 23.18±2.64 years, heights 173.0±4.03cm and weights 64.31±5.97kg. AMIT force-platform and Penny electrical goniometer were used to record ground reaction forces and angular displacements. The short-stretch DJ endured larger work intensity of initial eccentric phase at the 25ms and PK2, developed larger force and loading rate at the end of pre-stretch and enhanced concentric average force. Although the long-stretch DJ didn't develop larger forces during concentric and concentric phases, it had a longer supporting time that helped to increase the momentum and ended up with the higher flight-height. When we practice SSC exercise with the intent to increase the concentric force, the method of short-stretch DJ should be adopted. If the purpose is to jump higher, the long-stretch DJ is recommended.

KEY WORDS: work load, work intensity, force, loading rate, momentum, flight height

INTRODUCTION: Stretch-shortening cycle (SSC) exercise is one of the methods to train explosive strength. Rack and Westbury (1974) proposed the ideal of short-range stiffness. When muscle is stretched beyond the short-range, the number of cross bridges will be reduced and the result is a decline of force. Stretch amplitude should be a critical factor to determine the force and performance of SSC movement (Bosco 1981).
First peak force (PK1) and second peak force (PK2) are often used to present the load during landing (Nigg 1985). PK1 isn't easy to identify in this experiment, so the force produced at 25ms was chosen to represent PK1. PK2 appears at the moment of heel landing. These two forces occurred during the beginning of eccentric phase. The force developed at the end of stretch (initial force of concentric phase) is an important index, because the aim of an eccentric phase is to enhance this force consequently to increase positive influence on concentric average force. Fleck & Kraemer (1987) thought that the work intensity was determined not only by load but also by velocity. When muscle is stretched, the force developed during a period of time is called loading rate. The unit of loading rate contains that of load and velocity, so loading rate can be an index of work intensity during stretching. The force and loading rate of 25ms, PK2 and end of pre-stretch were used to examine the work load and intensity of the short-stretch drop jump (DJ) and long-stretch DJ.
The final result of performance is the flight-height which is determined by momentum not force. Force is only one of the determinants of momentum. Momentum and flight-height were examined to identify the performance between of the short-stretch DJ and long-stretch DJ.

METHODS: Short-stretch DJ and long-stretch DJ at the height of 20, 40 and 60cm were performed by 11 subjects of jumpers and sprinters with average ages 23.18±2.64 years, heights 173.0±4.03cm and weights 64.31±5.97kg. AMIT force-platform and Penny electrical goniometer were used to record ground reaction forces and angular displacements. The sampling rate was 1000 HZ and the low pass was 10HZ. SPSS software was adopted to calculate the values of the parameters and repeated measures t-test was used to test the difference between short and long stretch DJ. The significance level was set at.05.

RESULTS AND DISCUSSION: **The supporting time and stretch amplitude.** When implementing the short-stretch DJ, the subjects were told to jump with a knee angle smaller than 75 degrees and to jump over 85 degrees for the long-stretch DJ. The subjects had to jump as fast and as high as possible. The average of angular displacement of short-stretch DJ of all height was 70.4±4.9 degree and that of long-stretch DJ was 90.9±4.7 degrees. The supporting time between landing and take-off of short-stretch DJ of all heights was 388±43 ms and 593±43ms was produced by long-stretch DJ.

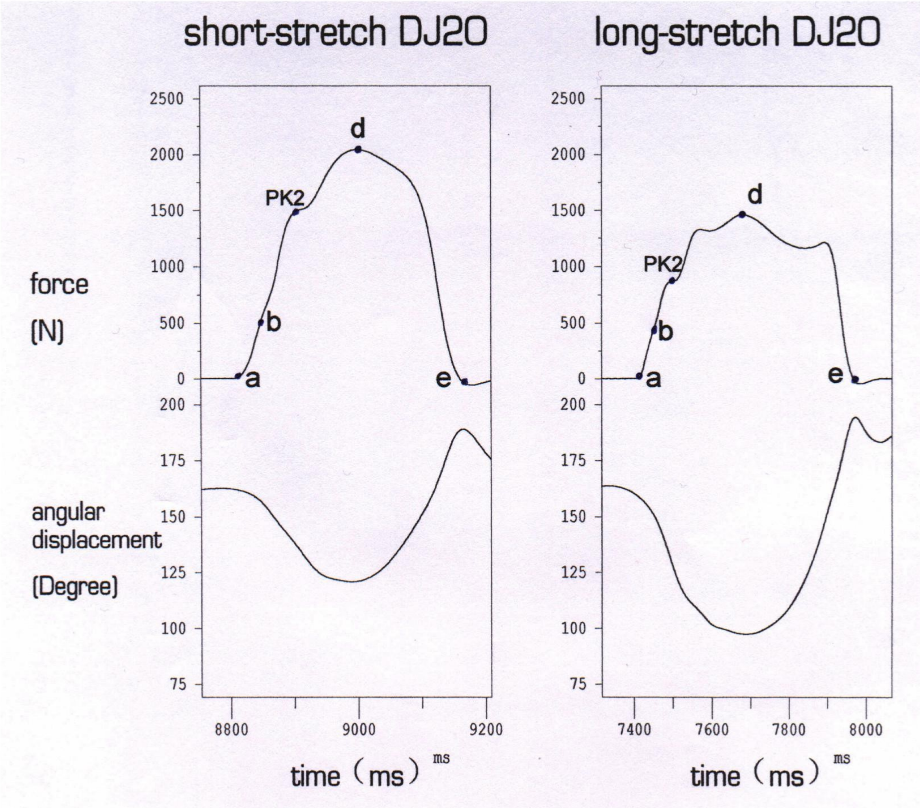

Figure1 - The curves of ground reaction force and angular displacement of short-stretch and long-stretch DJ. a is the contact of landing. b, c and d are the forces developed at 25ms, PK2 and the end of pre-stretch. e is the point of take-off.

The work intensity of short-stretch DJ and long-stretch DJ. The force and loading rates of 25ms, PK2 and the end of pre-stretch of short-stretch DJ were larger than those of long-stretch DJ from the height of 20, 40 and 60cm (see Table1). Nigg (1985) found that the passive force appears between 0 to 50~75ms after the stretch began, therefore, the force at 25ms happened within the period of the passive force. PK2 appeared around the beginning of the active force (or the end of passive force), because the latency was 68~79msent. The forces at 25ms and PK2 were produced at the beginning of eccentric phase which passive force occurs. For SSC movement, the aim of an eccentric phase is to maximize the force developed at the end of pre-stretch, because it can increase or decrease concentric average force. The larger force developed at the end of pre-stretch will increase of concentric average force. From the results of this experiment, we found the work load and intensity of short-stretch DJ were larger than those of the long-stretch DJ, because it's larger forces and loading-rates at 25ms, PK2 and the end of pre-stretch. There are two explanations for this phenomenon: 1) Long–stretch DJ spent longer time to get larger cushion at the same load (same mass from the same height), therefore, it bore less work intensity than the short-stretch DJ. 2). Because the long-stretch DJ was further stretched beyond the short-range elastic stiffness which caused more cross-bridge detachment and sarcomere 'give' (Flitney & Hirst, 1978), therefore, it's force declined more than that of short-stretch DJ. In summary, the short-stretch DJ could develop larger force and work intensity than the long-stretch DJ.

Table1 The Comparison of Work Intensity between Short-stretch and Long-stretch DJ

	Jump method (average±SD)		
DJ height	DJ20	DJ40	DJ60
(25ms loading rate Unit: body weight /Second)			
Short-stretch DJ	24.42±4.27	39.98±7.78	56.30±7.42
Long-stretch DJ	19.85±4.28	33.55±5.32	47.06±4.98
P value	.021	.052	.003
(25ms force Unit: body weight)			
Short-stretch DJ	0.61±0.11	0.99±.19	1.41±.19
Long-stretch DJ	0.50±0.11	.85±.14	1.18±.12
P value	.021	.052	.003
(PK2 loading rate Unit: B.W./S.)			
Short-stretch DJ	27.26±7.47	41.99±8.61	53.64±8.88
Long-stretch DJ	20.19±3.46	34.24±6.19	44.90±5.70
P value	.010	.025	.012
(force of PK2 Unit:B.W.)			
Short-stretch DJ	2.11±.36	3.09±.39	3.66±.40
Long-stretch DJ	1.64±.26	2.37±.30	2.95±.25
P value	.003	.000	.000
(loading rate at the end of pre-stretch Unit: B.W./S.)			
Short-stretch DJ	16.23±3.92	15.75±4.50	15.02±4.98
Long-stretch DJ	9.53±2.39	8.79±1.18	8.74±1.07
P value	.000	.000	.001
(force at the end of pre-stretch Unit:B.W.)			
Short-stretch DJ	3.04±0.35	3.09±0.42	2.96±0.40
Long-stretch DJ	2.52±0.28	2.56±0.21	2.55±0.33
P value	.001	.001	.018

Table2 Exercise performance of short-stretch and long-stretch DJ

	Jump method (average±SD)		
DJ height	DJ20	DJ40	DJ60
(concentric average force Unit: B.W.)			
Short-stretch DJ	2.39±0.12	2.35±0.21	2.30±0.20
Long-stretch DJ	2.02±0.17	1.94±0.08	1.93±0.05
P value	.003	.002	.000
(momentum Unit:kg*m/s)			
Short-stretch DJ	555±91	612±94	643±86
Long-stretch DJ	695±117	740±100	783±92
P value	.003	.006	.001
(flight height Unit:cm)			
Short-stretch DJ	39.1±3.6	40.7±3.3	39.7±3.5
Long-stretch DJ	44.1±3.2	44.4±3.6	43.5±3.1
P value	.003	.019	.014

The exercise performance of short stretch DJ and long stretch DJ. The concentric average force, momentum and flight-height were examined to understand the performance between the two DJs of different stretch amplitude. The concentric average force of the short-stretch DJ was significantly larger than that of the long-stretch DJ (see Table3). Because of the larger force developed at the end of pre-stretch, the higher concentric average force developed by short-stretch DJ was expected. On the other hand, the flight-height produced by the long-stretch DJ was significantly higher than those of short-stretch DJ at the heights of 20, 40 and 60cm because of larger momentum (see Table2). The momentum in this experiment was calculated by integrating the ground reaction force within the supporting time between landing and take-off. Although the long-stretch DJ did not have the larger eccentric and concentric force, the longer supporting time promoted the impulse which increased the momentum. Under the same mass, the increase of momentum finally increased the take-off velocity and the subjects jumped higher.

CONCLUSION: 1) The short-stretch DJ endured larger work intensity than the long-stretch DJ because of the larger loading rate at the 25ms, PK2 and the end of pre-stretch. 2) The short-stretch DJ produced the larger force at the end of pre-stretch and concentric average force. 3) The long-stretch DJ didn't have the larger concentric average force, but had a longer supporting time which increased the momentum, therefore, it ended up with the higher flight height. 4) When we practice SSC exercise with the intent to increase the concentric force, the method of short-stretch DJ should be adopted. If the purpose is to jump higher, the long-stretch DJ is recommended.

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