

MODELING RELATIONSHIPS BETWEEN JUMP HEIGHT, GROUND CONTACT TIME, REACTIVITY AND STIFFNESS.

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INTRODUCTION

Plyometric muscular actions involve the stretch shortening cycle (SSC) in a sports specific manner. In some cases, it is very important to jump high (volleyball, basketball, ski jumping, etc.). In other cases, it is important to jump as high as possible with time constraints and consequently short and intense impulses (rebound, volleyball, etc.) are needed. In other contexts it could also be important to have very short and stiff impulse (sprinting, rebounds, tennis, etc.). Recent research has demonstrated that muscular stiffness during a jump was not linked to the jump performance [1]. A practical consequence is that both training modalities are very different for these two muscular qualities. Another consequence is that training follow up should take into account muscular qualities required for performance. Traditional jumping tests such as the squat jump and countermovement jumps provide incomplete information. Reactivity tests are difficult to standardize and could lack reliability. Stiffness appears very difficult to assess in field conditions. The aim of this study was to develop an original plyometric test that assesses at the same time the four main SSC characteristics: jumping high, ground contact time, reactivity and stiffness.

METHODS

Twenty healthy subjects (22±2 yr, 1.73±0.09 m, 65±11 kg) participated in this study and were tested twice, one week apart, using the same exercise modalities. The testing protocol started with squat jump (SJ) and counter movement jump (CMJ) tests. Three familiarization trials were followed by three measured trials. After these two tests, all subjects performed the “plyometric profile” that consisted of continuous jump tests (CJ) following 5 different modalities. For each modality, subjects received a specific instruction:

1. CJ-CT: jump 6 times with the intention to reduce as much as possible the ground contact time. Jump height has to be very low.
2. CJ-CTR: jump 6 times with the intention to reduce as much as possible the ground contact time. Jump height has to be a little higher.
3. CJ-R: jump 6 times with the intention to reduce as much as possible the ground contact time and at the same time jump as high as possible.
4. CJ-RJH: jump 6 times with the intention to jump as high as possible. The ground contact time can be increased and a little knee flexion is recommended
5. CJ-JH: jump 6 times with the intention to jump as high as possible. Take time to flex the knee at each landing

Each modality was performed two times. Ten subjects started with the CJ-CT and followed the continuum until CJ-JH while the ten other subjects did the opposite.

The Myotest pro accelerometer (Myotest, Switzerland) was vertically attached to an elastic belt on the subject's hip, according to the manufacturer's instructions. Vertical jump height (JH) was measured for all the tests. Ground contact time (CT), reactivity index (RI = flying time/CT) and stiffness (Stif = Fmax/vertical displacement during impulse) were also assessed for all continuous jumps. Classical descriptive statistics were used in the present study. Inter-session reproducibility was measured with a specific coefficient of variation (CV)[2]. A dependent t-test was used to determine significant differences. Mathematical modeling was used to describe the relationships between JH, CT, RI and Stif.

RESULTS

Table 1 presents descriptive data and coefficients of variation for the four parameters measured at each continuous jump test. JH and CT increased from CJ-CT to CJ-JH while Stif decreased ($p<0.001$). RI reached the highest value at CJ-R. JH reproducibility was excellent for CJ-RJH and CJ-JH. CT reproducibility was good for CJ-CT and CJ-TCR. In comparison with other parameters, Stif reproducibility was lower with CV's ranging from 17 to 48%. There was no significant difference between session 1 and session 2. CMJ jumping height (33.7 ± 5.8) presented no difference with CJ-JH but was significantly greater than SJ ($32.8\pm5.5\text{cm}$) ($p<0.05$).

Table 1 – Descriptive data and reproducibility analysis (CV) for the “plyometric profile” test.

		CJ-CT	CJ-TCR	CJ-R	CJ-RJH	CJ-JH
JH(cm)	Mean(SD)	6.6 (2.0)	14.1 (3.0)	24.3 (4.0)	31.3 (5.3)	33.0 (5.9)
	CV (%)	28	18	11	5	3
CT(ms)	Mean(SD)	108 (11)	117 (13)	148 (29)	277 (75)	446 (85)
	CV (%)	6	8	11	25	15
RI	Mean(SD)	2.1 (0.3)	2.9 (0.4)	3.1 (0.5)	2.0 (0.5)	1.2 (0.3)
	CV (%)	10	8	7	25	17
Stif ($\text{kN}\cdot\text{m}^{-1}$)	Mean(SD)	90 (23)	67 (19)	42 (15)	13 (7)	5 (2)
	CV (%)	17	20	24	48	32

The figures presented all the relationships established between JH, CT, RI and Stif after mathematical modeling.

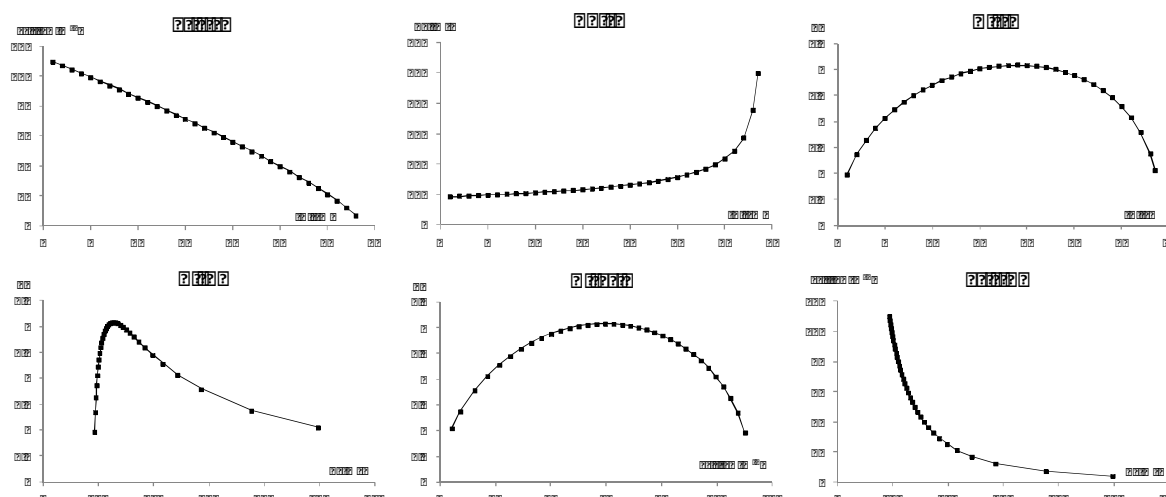


Figure 1 – Relationships between JH, CT, RI and Stif established after mathematical modeling.

DISCUSSION

The “plyometric profile” test built on five progressive modalities of continuous jumps allowed measurement of the variation of four plyometric parameters (JH, CT, RI and Stif) inside a continuum going from maximal jumping height to minimal ground contact time. Mathematical modeling was then successfully used to describe all the relationships between these four parameters. Such an approach is not limiting the athlete evaluation to jumping height ability but also affords measurement of reactivity and stiffness qualities, which are important in many sport actions. The “plyometric profile” could be performed in the field with a simple and accessible accelerometer. However, mathematical modeling requires specific software that needs to be developed.

CONCLUSION

The present study presents the “plyometric profile” potential. It could be very useful for plyometric acute assessment and longitudinal follow up.

REFERENCES

- [1] Jidovtseff et al. Comp Meth Biomech Biomed Eng. 13 (S1): 77-78, 2010.
- [2] Jidovtseff et al. Isokinetics Exerc Sci 14: 53–62, 2006.