Asian Journal of Sports Medicine

ORIGINAL ARTICLE

Possibility of Delay in the Super-Compensation Phase due to Aging in Jump Practice

Tadahiko Mitsumune*, MD, PhD; Eizoh Kayashima, MD

Authors' Affiliation:

Junpukai Health Maintenance Center, Japan

Authors' Contribution

A Concept / Design
B Acquisition of Data
C Data Analysis / Interpretation
D Manuscript Preparation
E Critical Revision of the Manuscript
F Funds Collection
G Approval of the Article

*** Corresponding Author;**

Address: Junpukai Health Maintenance Center, 2-3-1 Daiku, Kita-ku, Okayama 700-0913, Japan

E-mail: jbh01210@nifty.com

Received: *Dec 24, 2012*
Accepted: Aug 19, 2013
Available Online: *20 Sep, 2013*

Abstract

Purpose: **To investigate the possibility of a delay in the super-compensation phase due to aging in jump practice.**

Methods: **This study evaluated records in three phases (approximately every five years) of a man who had been participating in Masters Athletics for over 20 years. After correcting for air temperature, which would influence the distance on a standing five-step jump using simple regression analysis, the performance curve of the super-compensation phase was calculated at each phase by curvilinear estimation to assess the relationship between the training interval and distance on the standing five-step jump.**

Results: **A peak distance on the standing five-step jump was achieved after a training interval of 60 hours in the first phase; 75 hours in the second phase; and 88 hours in the third phase. That is, the peak distance tended to delay with aging.**

Conclusion: **It may be suggested that the super-compensation period would be delayed by aging in jump practice. We would like master athletes to refer this result and improve their performance.**

Key Words: Master Athlete; Athletic Training; Triple Jump; Curvilinear Estimation; Exercise

Asian Journal of Sports Medicine, Volume 4 (Number 4), December 2013, Pages: 295-300

INTRODUCTION

When a muscle receives an unusually strong load (overload), some of the muscle fibers are damaged and the muscle becomes fatigued; then, the muscular power initially decreases. Thereafter, the muscle recovers to the previous level in approximately 36-72 hours. Subsequently, muscle fiber strength starts to exceed the previous level in preparation for receiving a similar load again. This phenomenon is called super-compensation [1-3].

The training phenomenon called super-compensation was described by Folbrot in 1941 [4], and later discussed by Selye [5], who called it general adaptation syndrome. Yakovlev [6] classified the super-compensation cycle of a training session into four stages as follows: (phase 1: duration of 1 to 2 hours) fatigue after training; (phase 2: duration of 24 to 48 hours) compensation (rest) phase; (phase 3: duration of 36 to 72 hours) a rebounding or super-compensation of performance; and (phase 4: duration of 3 to 7 days) involution which is a decrease in the physiological benefits obtained during the super-compensation phase. This involution occurs when the athlete does not apply another stimulus within the optimal time (during the super-compensation phase).

Variations in the duration of the super-compensation phase depend on the type and intensity of training. For instance, following a medium-intensity aerobic endurance training session, super-compensation may occur after approximately six to eight hours. More intense activity that also places a high demand on the central nervous system may require more than 24 hours, sometimes as much as 48 hours, for super-compensation to occur [7]. Thereafter, the force-generation capacity returns to the baseline by 72 hours post-exercise [8].

If re-loading on the muscle is repeated during this super-compensation phase, the muscle volume and muscular power can be gradually increased. Therefore, for the improvement of physical strength, it is important to identify the super-compensation phase. However, while we have been observing athletes for a long time, we have received the impression that the super-compensation period becomes delayed with aging.

In this study, we researched the super-compensation phase during the jump practice of a middle-aged triple jumper, and followed up his records for about ten years.

METHODS AND SUBJECTS

A participant is a man who was born in 1953 and has been participating in Masters Athletics, spanning more than 20 years. He set a triple jump record of 11 meters and 13 centimeters, corresponding to the 14th world-ranking place in Masters Athletics M55 (55~59 years old), in 2008.

He performed 95 jump practices in 2000 (first period), 115 jump practices in 2006 (second period), and 112 jump practices in 2011 (third period). We used standing five-step jump records during each period for this investigation.

For each period, his basic training menu was as follows: warming up including static stretching; jogs; sprint drills; a 200-meter tempo run; a 150-meter tempo run; a 100-meter dash; hopping; bounding; standing five-step jump; and triple jump with a five-step approach run.

During this study, he did not use any particular restoration techniques including icing, massage, or special nutritional practices such as carbohydrate-loading. For these periods, his body weight was stable (Table 1), and he did not have a severe injury.

Statistics:

Analyses of variance were used to analyze records for the standing five-step jump under each condition in each phase. After correcting for air temperature, which would influence the distance on the standing five-step jump using simple regression analysis, the performance curve of the super-compensation phase was calculated at each phase by curvilinear estimation to assess the relationship between the training interval and distance on the standing five-step jump. And we estimated the top of the curvilinear as the super-compensation phase. All statistical analyses were performed with SPSS for Windows (Version 11.0, SPSS Inc.). All tests were interpreted using a significance level of $P<0.05$.

RESULTS

Annual triple jump records of the subject are shown in Fig. 1. His records decreased gradually with his age. Basic data in each phase are shown in Table 1. Standing five-step jump records tended to decrease as the phase advanced. Records for the standing five-step jump under each condition are shown in Table 2. Each record was significantly better as the temperature was higher in every phase.

Table 1: Basic data in each phase

	First stage(2000)	Second stage (2006)	Third stage(2011)
Standing five-step jump (m)	13.23 (0.17)	13.06 (0.13)	13.02 (0.16)
Air temperature (°C)	18.7 (8.7)	17.9 (7.9)	17.6 (8.6)
Body weight (kg)	59.1 (0.6)	58.4 (0.5)	58.0 (0.6)
Practice interval (hours)	81.2 (37.3)	74.1 (18.4)	76.9 (17.7)

Values are presented mean ± standard deviation

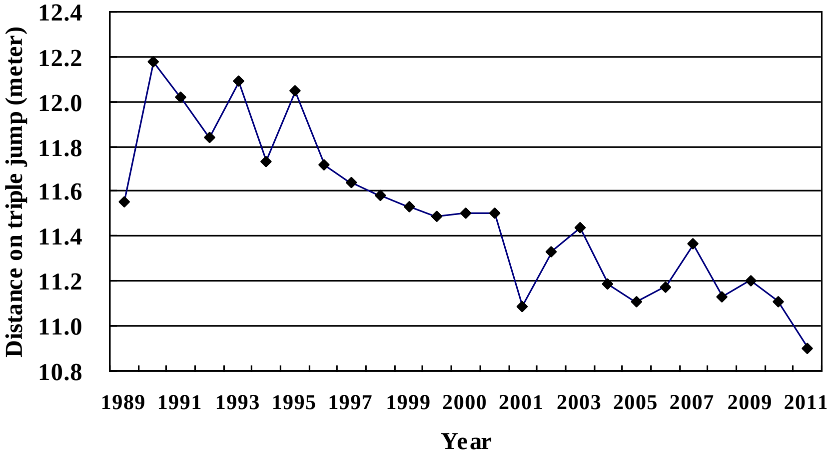


Fig. 1: Annual records of triple jump

Monthly records for the standing five-step jump in each phase are shown in Fig. 2. The records in every phase tended to be better in summer than in winter.

As the results of simple regression analysis, the air temperature was a significant factor influencing the records in every phase (Table 3). That is, each record was significantly better as the temperature increased. In the first phase, there was a 0.89cm change in the distance due to an air temperature change of 1ºC; in the second phase, there was a 0.68cm change in the distance due to an air temperature change of 1ºC; in the third phase, there was a 0.98-cm change in the distance due to an air temperature change of 1ºC. The regression coefficient in each phase was 0.450 for the first phase; 0.397 for the second phase; 0.724 for the third phase. Therefore, we were able to explain 20, 14, and 53%, respectively, of the correction with only the air temperature.

As the results of a curvilinear estimation of the relationship between the training interval and distance on the standing five-step jump after correcting for the air temperature, a quadratic equation was adapted in each phase; bell-shaped quadratic expressions were drawn from the records as shown in Fig. 3. A peak distance on the standing five-step jump was achieved after a training interval of 60 hours in the first phase; 75 hours in the second phase; and 88 hours in the third phase. That is, the peak distance tended to be delayed with aging.

Table 2: Distance on standing five-step jump in each phase

Parameter	First stage(2000)			Second stage (2006)			Third stage(2011)		
	no	Record(meter)	*P*-value*	no	Record (meter)	*P*-Value*	no	Record(meter)	*P*-Value*
Practice interval (PT) (hours)									
≤48	11	13.15 (0.05)		8	13.08 (0.08)		3	12.78 (0.14)	
48<PT≤72	36	13.31 (0.04)	0.02	71	13.07 (0.02)	0.07	61	13.03 (0.02)	0.05
72<PT≤96	24	13.22 (0.02)		22	13.07 (0.03)		38	13.04 (0.02)	
96<	24	13.18 (0.03)		14	12.95 (0.05)		10	12.99 (0.04)	
Air temperature (T) (°C)									
<10	21	13.15 (0.03)		21	12.96 (0.03)		25	12.84 (0.03)	
10≤ T<20	25	13.15 (0.03)	<0.001	39	13.01 (0.02)	<0.001	34	12.99 (0.02)	<0.001
20≤ T<30	35	13.29 (0.03)		44	13.11 (0.03)		44	13.10 (0.02)	
30≤	14	13.38 (0.05)		11	13.19 (0.01)		9	13.21 (0.05)	

Values are presented mean ± standard error; * Analyses of variance were used

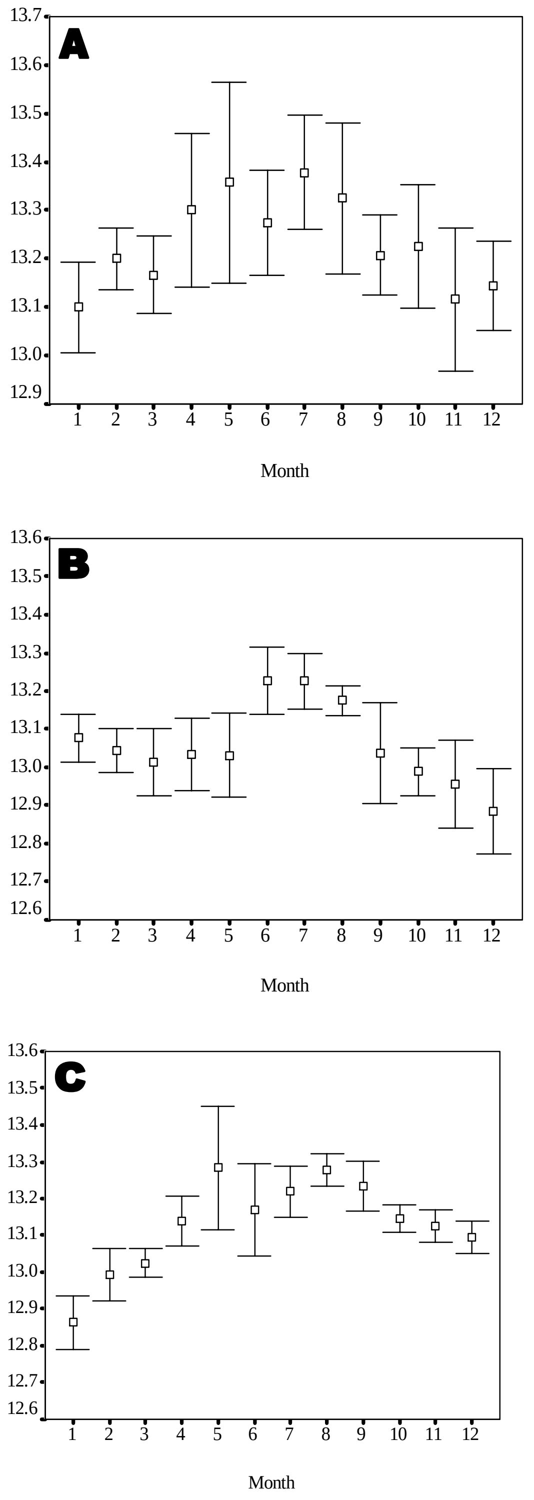
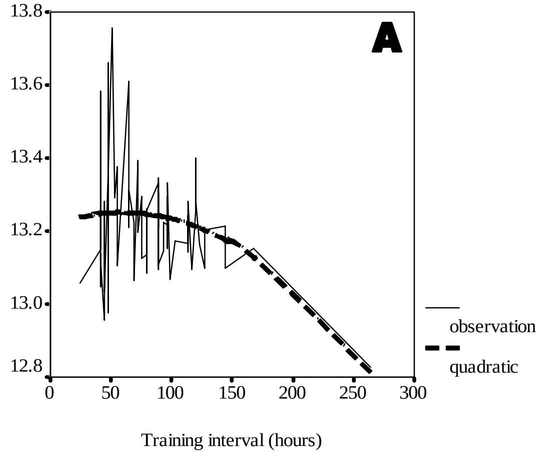
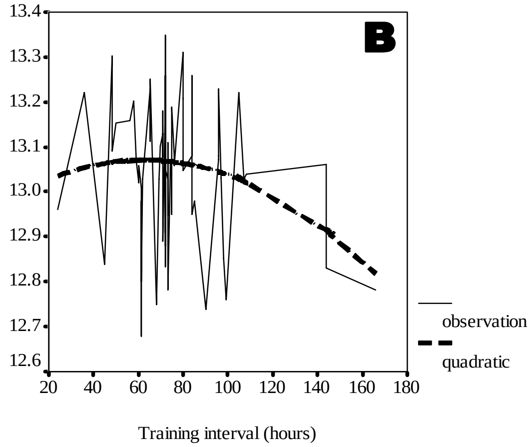


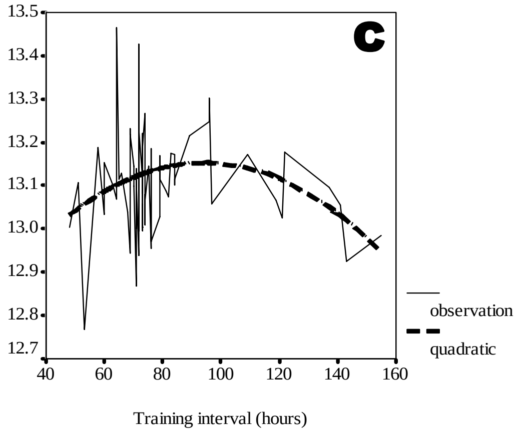
Fig. 2: Monthly records of distances achieved on standing five-step jump in 2000 (Panel A), 2006 (Panel B), and 2011 (Panel C)



quadratic equation: $Y=13.2141+0.0012X-0.00001X^2=-0.00001(X-60)^2+13.5741$ (P=0.01)



quadratic equation: $Y=12.9784+0.0030X-0.00002X^2=-0.00002(X-75)^2+13.0909$ (P=0.04)



quadratic equation: $Y=12.6537+0.0106X-0.00006X^2=-0.00006(X-88.3)^2+13.1215$ (P=0.02)

Fig. 3: Relationship between training interval and distance on standing five-step jump in 2000 (Panel A), 2006 (Panel B), and 2011 (Panel C)

Table 3: Results of simple linear regression analysis of distance on standing five-step jump by air temperature in each phase

Parameter	Records of standing five-step jump β	P-value
Air temperature in 2000 (first phase) **regression coefficient (R)=0.450, R^2=0.202**	0.0089	<0.001
Air temperature in 2006 (second phase) **regression coefficient (R)=0.379, R^2=0.144**	0.0068	<0.001
Air temperature in 2011 (third phase) **regression coefficient (R)=0.724, R^2=0.525**	0.0098	<0.001

β: regression coefficient

DISCUSSION

If we estimate the top of the curvilinear in the distance on the standing five-step jump as the super-compensation phase, a super-compensation phase of 60 hours in the first phase; 75 hours in the second phase; and 88 hours in the third phase were long as the super-compensation phase. As it is said that more intense activity that also places a high demand on the central nervous system may require more than 24 hours, sometimes as much as 48 hours, for super-compensation to occur [7], it seems that jump practice in this study exactly corresponds to this.

The super-compensation phases presumed by the calculation based on the standing five-step jump records in this study delayed with age. The possibility that a true super-compensation period also delays according to age was suggested. Therefore, we should presume the super-compensation period by adding an aging factor to the difference of items.

It was reported that, in short-term exercises, such as jumping and sprinting, performance is reduced at a low muscle temperature and enhanced at a muscle temperature above normal, primarily as a result of variation in the maximal dynamic strength [9]. Therefore, we analyzed data on correcting for the air temperature in this study. However, the regression coefficient in each phase was 0.450 for the first phase; 0.397 for the second phase; 0.724 for the third phase. Therefore, we were able to explain 20, 14, and 53%, respectively, of the correction with only the air temperature. Therefore, we consider that the records should be revised by adding other factors influencing the records to improve the accuracy of analysis.

It is considered that the time which the athlete needs to recover his/her performance is affected by many factors, as follows: the training status of the athlete [10], the muscular contraction type encountered during the training session [11], the use of restoration techniques, and the nutritional status of the athlete [12,13]. Additionally, humidity, air velocity, body weight, sleeping time, and the psychological condition might also be related to the records. We would like to perform further research, because another factor influencing the distance on the standing five-step jump may exist.

Since all data in this study were obtained from one individual, we did not have to consider individual variations, but we were then not able to estimate individual variations in the super-compensation period. We consider it a limitation of this research.

We consider that these findings could be used as practical applications for athletes or elderly people participating in other sports without being limited to a jumping event. However, since there are individual variations and/or differences in exercise intensity, it will be important for individuals to accumulate their own data. We expect that replication studies using considerably more data including many more athletes will be performed.

CONCLUSION

It may be suggested that the super-compensation period would be delayed by aging in jump practice. We would like master athletes to refer to this result and improve their performance.

ACKNOWLEDGMENTS

We are grateful to Mr. Motomi Mohri for useful suggestions.

Conflict of interests: None

REFERENCES

[1] Burke L, Deakin V. Clinical Sports Nutrition. Roseville, Australia: McGraw-Hill Australia, 2000.

[2] Coyle EF. Timing and method of increased carbohydrate intake to cope with heavy training, competition and recovery. *J Sports Sci* 1991;9:29-51.

[3] Costill DL, Pascoe DD, Fink WJ, et al. Impaired muscle glycogen resynthesis after eccentric exercise. *J Appl Physiol* 1990;69:46-50.

[4] Siff MC, Verkhoshansky YV. Supertraining. Denver: Supertraining International Co. 1999.

[5] Selye H. The Stress of Life. New York: McGraw Hill. 1956.

[6] Yakovlev N. Sports biochemistry. Leipzig: Deutche Hochschule für Körpekultur. 1967.

[7] Nicol C, Avela J, Komi PV. The stretch-shortening cycle: a model to study naturally occurring neuromuscular fatigue. *Sports Med* 2006;36:977-99.

[8] Zainuddin Z, Sacco P, Newton M, et al. Light concentric exercise has a temporarily analgesic effect on delayed-onset muscle soreness, but no effect on recovery from eccentric exercise. *Appl Physiol Nutr Metab* 2006;31:126-34.

[9] Bergh U, Ekblom B: Influence of muscle temperature on maximal muscle strength and power output in human skeletal muscles. *Acta Physiol Scand* 1979;107:33-7.

[10] Garrandes F, Colson SS, Pensini M, et al. Neuromuscular fatigue profile in endurance-trained and power-trained athletes. *Med Sci Sports Exerc* 2007;39:149-58.

[11] Michaut A, Pousson M, Millet G, et al. Maximal voluntary eccentric, isometric and concentric torque recovery following a concentric isokinetic exercise. *Int J Sports Med* 2003;24:51-6.

[12] Costill DL, Sherman WM, Fink WJ, et al. The role of dietary carbohydrates in muscle glycogen resynthesis after strenuous running. *Am J Clin Nutr* 1981;34:1831-6.

[13] Burke LM: Nutrition for post-exercise recovery. *Aus J Sci Med Sports* 1997;29:3-10.