VERTICAL JUMP PERFORMANCE AND POWER DROP AFTER 35 DAYS OF BED REST

Gregor Cankar*, **Boštjan Šimunič*** , **Jörn Rittweger****, and **Rado Pišot***

* Institute of Kinesiology Research, Science and Research Centre of Koper, University of Primorska, Koper, Slovenia

** Institute for Biomedical Research into Human Movement and Health, Manchester Metropolitan University, UK

Abstract

Physical – sport inactivity is often associated with loss of muscle mass, positive energy balance, fat gain, injuries, motor incompetence, and many others negative effects. The goal of this study was to evaluate loss of muscle function and performance as a response to total physical inactivity. Ten healthy male volunteers (age: 23.3 ± 2.2 years; body height: 179 ± 7.1 cm; body mass: 75.2 ± 9.3 kg) were measured before and after 35 days of horizontal bed rest. Energy intake was adapted from the beginning of the bed rest and associated with weekly changes in body mass and fat mass. Peak muscle power and maximal jump height was measured during vertical jump test, performed before and after bed rest. Maximum jumping power and jumping height decreased significantly after bed rest, for 10 $W \cdot kg^{-1}$ (19.2 %; P<0.001) and 11.2 (22 %; P<0.001), respectively. Inter subjects' variability of the jumping height results was in the range from 8.6 % to 49.1 % and for jumping height from 6.8 % to 31.3 %. Results of this study confirm that vertical jump test demands vigorous human performance and should be conducted after bed rest studies in special care and considering huge inter subject variability in designing studies.

Keywords: bed rest, skeletal muscle, vertical jump, jump power, jump height

Introduction

Nowadays many athletes have problems with injuries which consequently lead to loss of training days, muscle mass, muscle strength, and consequently to loss of performance. Lack of sport exercise leading into unbalanced (positive) energy intake reflects mainly in fat deposits. Sport exercise physiology is well investigated area in science and sport. To understand positive effects of sport activity we have to understand also effects after periods of inactivity. There are many different approaches to study how physical inactivity reflects on human organism. Some scientists have been studying effects of long duration space flights (Pavy-Le Traon et al.,1998; Le Blanc et al., 2000a; Blottner et al., 2006), other studies were done with simulation of weightlessness (Adams et al., 2003; Mekjavić et al., 2005; Rittweger et al., 2006; Rittweger et al., 2007; Pišot et al., 2008), or immobilization of healthy (Rittweger et al., 2006; Ferrando et al., 1996) or injured (Hyeteok et al., 2003; Pathare et al., 2005) body parts.

Recent findings have shown that effects of bed rest on human organism are similar as effects sedentary lifestyle and ageing, but different mechanisms involved. Effects can be seen in all human systems: loss of bone mass (Lang et al., 2004; Le Blanc et al., 2000a and 2000b), loss of muscle mass (Adams et al., 2003; Kawakami et al., 2001), changes in body composition (Kawakami et al., 2001; Kubo et al., 2004; Šimunič et al., 2008), loss of muscle function (Pathare et al., 2005; Duchateau et al., 1987; Alkner & Tesch, 2004; Lang et al., 2004) and impairment of cardiac circulatory system (Mekjavić et al., 2005).

Jumping power and jumping height is used as a performance test in many sports. Therefore, scientists use the test to evaluate short- and long- term adaptations on various training/detraining impulses. The data from different studies and within the same studies show great discrepancies. So far we know that muscle power declines with exposure to bed rest from 9 to 16 % per month (Rittweger et al., 2007; Ferretti et al., 2001), while jump height 10.7 % per month (Rittweger et al., 2007). Furthermore, Rittwegger et al. (2007) reports inter subjects' variations in loss of jump power and loss of jump height from 9 to 31 % and from 14 to 48 %, respectively. Additionally, scientists evaluate jump performance typically after 2 to 4 days after reambulation. Rittwegger et al. (2007) was the first to demonstrate jump power measurements immediately after reambulation. He reported particularly strong muscle soreness during the first days of recovery and therefore only 70% of jumps performed and some of them performed sub-maximal.

Maximal jump test is very vigorous performance test containing elements of explosiveness with maximal force production in short time and is widely used in sports. Therefore, our concern was in test results obtained immediately after bed rest deconditioning and reporting inter subjects' variability.

Methods

PARTICIPANTS: Ten healthy males without history of cardiovascular and musculoskeletal illnesses were selected for study of 35 days of 6° head down tilt bed rest. Bed rest study was performed in Orthopaedic Hospital Valdoltra. The experimental protocol was approved by the Ethical Committee of the University of Ljubljana, Slovenia and conformed to the standards set by the Declaration of Helsinki (2002). All volunteers were previously informed about procedures and risk factor involved and submitted written informed consent.

VERTICAL JUMP TEST: Jump test was performed before bed rest (BDC) and immediately after reambulation (POST). Vertical countermovement jumps, with athletic shoes and with the hands posed on the hips, were performed on a 'Leonardo' ground reaction platform (Novotec Medical, Pforzheim, Germany). Every participant performed three maximal jumps from which highest jump and corresponding power was selected for the further analyses. Data were sampled at 2000 Hz and stored on a PC. The instruction to jump was to elevate the head as high as possible.

OTHER MEASUREMENTS: Body height and weight were measured with standard tools. Muscle mass and fat mass were measured with bioimpedance method (Maltron BioScan 916S, UK).

STATISTICS: Personal data are presented as mean ± standard deviation, while variables' data as mean ± standard error. Results were analyzed with a repeated measures analysis of variance (ANOVA). All comparisons were considered statistically significant at the conventional 0.05 level. Statistical analysis was performed using SPSS statistical software (version 15; SPSS, Inc., Chicago, IL).

Results

All data are summarized in table 1. Participants have lost 3 kg (4 %; $P<0.001$) of body weight after 35 days of bed rest. Muscle mass after bed rest dropped for 1.1 kg (-3.4 %; $P<0.001$), while fat mass did not decrease significantly ($P=0.598$).

Table 1: Average data collection before and immediately after bed rest

	BDC	POST	P
Height / cm	179.0 ± 7.1	-	-
Body Weight / kg	75.2 ± 9.3	72.2 ± 8.7	0.000
Muscle mass / kg	32.0 ± 3.3	30.9 ± 3.2	0.000
Fat mass / %	15.8 ±3.6	15.7 ± 3.2	0.598
Jumping Power / W·kg^{-1}	52.0 ± 2.7	42.0 ± 1.3	0.001
Jumping Height / cm	50.8 ± 2.4	39.6 ± 2.3	0.000

BDC: Baseline Data Collection; POST: After bed rest data collection; P statistical significance

Maximum jumping power and jumping height (Figures 1, 2) decreased significantly after bed rest. We noted reduction of relative jumping power for 10 W·kg^{-1} (19.2 %; P<0.001) and similar reduction of jump height of 11.2 (22 %; P<0.001).

Inter subjects' variability for jumping height and jumping power was from 8.6 % to 49.1 % and from 6.8 % to 31.3 %, respectively.

Discussion

In this study we evaluated performance drop in vertical jump after 35 days of physical inactivity. As far as we know there was very little known about human performance deterioration in early minutes after bed rest reambulation. On the other hand scientists also reports huge inter subject variability in the drop at maximal performance tests after bed rest studies. Therefore our aim was to establish immediate leg power and jumping height deterioration after 35 days of bed rest.

Our test was done within 30 min after reambulation, literally first 10 to 20 steps were made on ground reaction platform. We found decrease of peak jump relative power and jump height after 35 days of bed rest for 19.2 % and 22 %, respectively. Our findings are not in line with earlier reports made by Rittweger et al. (2007), where they found reduction of jump peak power and height, after 90 days of bed rest, by 25.8 % and 29.5 %, respectively. But are in line with Ferretti et al. (2001) where he found after 42 days of bed rest 22.7 % loss of maximal muscle power. He concluded that drop in calf plantar flexors cross sectional area can be explained as reduction of muscle power output, if appropriately normalized.

Figure 1: Maximum jump height before and after bed rest.

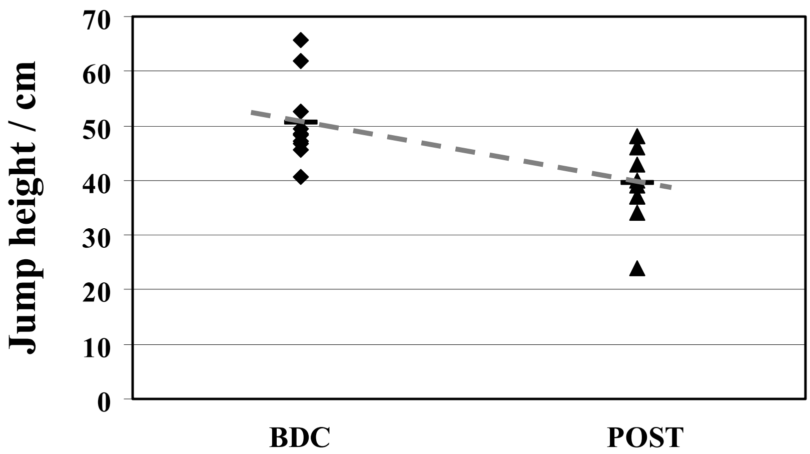
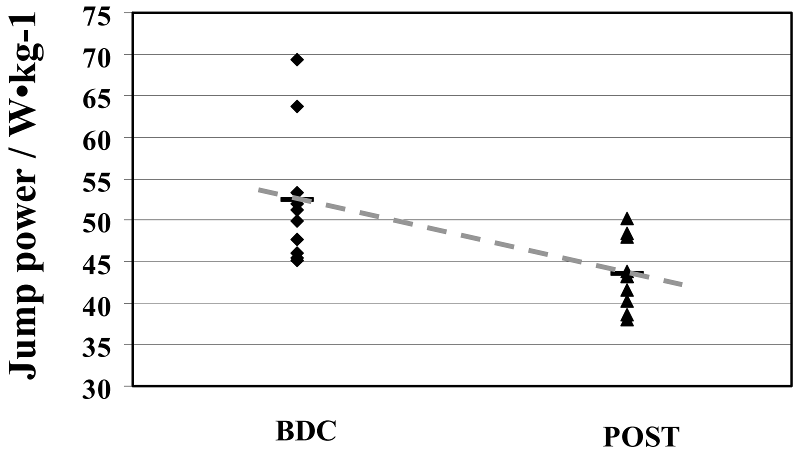


Figure 2: Maximum relative jump power before and after bed rest.



BDC: Baseline Data Collection; POST: After bed rest data collection;

Furthermore, inter subjects' variability was in line with findings of others. The lower and upper limit for jumping height and jumping relative leg power was from 8.6 % to 49.1 % and from 6.8 % to 31.3 %, respectively. Rittweger et al. (2007) reported similar variability in jumping power from 8 % to 31 %, while in jumping height from 13 % to 48 %. In our study one subject sprain his ankle but performed the jump test without pain. He reported the pain next day. Other subject next day complained about the pain in the instep area. After physician examination he could continue the other tests during following days. Both incidents confirmed that jump test demands vigorous human performance. Test as such is standard evaluation test not just in sport but also in space studies and therefore should be considered with special care. Large inter subjects' variability should be considered carefully before applying such test in future studies.

References

1. Adams, G.R., Caiozzo, V.J., Baldwin, K.M. (2003). Skeletal muscle unweighting: spaceflight and ground-based models. European Journal of Applied Physiology; 95: 2185–2201.
2. Alkner, B.A., Tesch, P.A. (2004). Efficacy of a gravity independent resistance exercise device as a countermeasure to muscle atrophy during 29-day bed rest. Acta physiologica scandinavica; 181: 345–357.
3. Blanc, S., Normand, S., Ritz, P., Pachiaudi, C., Vico, L., Gharib, C., et al. (1998). Energy and Water Metabolism, Body Composition, and Hormonal Changes Induced by 42 Days of Enforced Inactivity and Simulated Weightlessness. Journal of Clinical Endocrinology & Metabolism; 83(12): 4289–4297.
4. Blottner, D., Salanova, M., Püttmann, B., Schiff, G., Felsenberg, D., Buehring, B., et al. (2006). Human skeletal muscle structure and function preserved by vibration muscle exercise following 55 days of bed rest. European Journal of Applied Physiology; 97: 261–271.
5. Duchateau, J., Hainaut, K. (1987). Electrical and mechanical changes in immobilized human muscle. Journal of Applied Physiology; 62(6): 2168–2173.
6. Ferrando, A.A., Lane, H.W., Stuart, C.A., Davis-Street, J., Wolfe, R.R. (1996). Prolonged bed rest decreases skeletal muscle and whole body protein synthesis. American Journal of Physiology – Endocrinology and Metabolism; 270: 627–633.
7. Ferretti, G., Berg, H.E., Minetti, A.E., Moia, C., Rampichini, S., Narici, M.V. (2001). Maximal instantaneous muscular power after prolonged bed rest in humans. Journal of Applied Physiology. 90(2): 431–435.

8. Hyeteok, K., Iwasaki, K., Miyake, T., Shiozawa, T., Nozaki, S., Yajima, K. (2003). Changes in bone turnover markers during 14-day 6° headdown bed rest. Journal of Bone and Mineral Metabolism; 21: 311–315.
9. Kawakami, Y., Akima, H., Kubo, K., Muraoka, Y., Hasegawa, H., Kouzaki, M., et al. (2001). Changes in muscle size, architecture, and neural activation after 20 days of bed rest with and without resistance exercise. European Journal of Applied Physiology; 84: 7–12.
10. Kubo, K., Akima, H., Ushiyama, J., Tabata, I., Fukuoka, H., Kanehisa, H., et al. (2004). Effects of 20 days of bed rest on the viscoelastic properties of tendon structures in lower limb muscles. British Journal of Sports Medicine; 38: 324–330.
11. Lang, T., Le Blanc, A., Evans, H., Lu, Y., Genant, H., Yu, A. (2004). Cortical and trabecular bone mineral loss from the spine and hip in long-duration spaceflight. Journal of Bone and Mineral Metabolism; 19: 1006–1012.
12. Le Blanc, A., Schneider, V., Shackelford, L., West, S., Oganov, V., Bakulin, A., et al. (2000a). Bone mineral and lean tissue loss after long duration space flight. Journal of Musculoskeletal and Neuronal Interactions; 1(2):157–160.
13. Le Blanc, A., Lin, C., Shackelford, L., Sinitsyn, V., Evans, H., Belichenko, O., et al. (2000b). Muscle volume, MRI relaxation times (T2), and body composition after spaceflight. Journal of Applied Physiology; 89: 2158–2164.
14. Mekjavić, I.B., Golja, P., Tipton, M.J., Eiken, O. (2005). Human thermoregulatory function during exercise and immersion after 35 days of horizontal bed-rest and recovery. European Journal of Applied Physiology; 95:163–171.
15. Pathare, N., Walter, G.A., Stevens, J.E., Yang, Z., Okerke, E., Gibbs, J.D., et al. (2005). Changes in inorganic phosphate and force production in human skeletal muscle after cast immobilization. Journal of Applied Physiology; 98: 307–314.
16. Pavy-Le Traon, A., Sigaudo, D., Vasseur, P., Maillet, A., Fortrat, J.O., Hughson, R.L., et al. (1998). Cardiovascular responses to orthostatic tests after a 42-day head-down bed-rest. European Journal of Applied Physiology; 77: 50–59.
17. Pišot, R., Narici, M., Šimunič, B., DeBoer, M.D., Seynnes, O., Jurdana, M., Biolo, G., Mekjavić, I.B. (2008).Whole muscle contractile parameters and thickness loss during 35-day bed rest. European Journal of Applied Physiology; 104(2): 409–414.
18. Rittweger, J., Winwood, K., Seyness, O., De Boer, M., Wilks, D., Lea, R., Narici, M.V. (2006). Bone loss from the human distal tibia epiphysis during 24 days of unilateral limb suspension. Journal of Physiology; 577: 331–337.
19. Rittweger, J., Felsenberg, D., Maganaris, C.N., Ferretti, J.L. (2007). Vertical jump performance after 90 days bed rest with and without flywheel resistive exercise, including a 180 days follow-up. European Journal of Applied Physiology; 100: 427–436.
20. Ritz, P., Acheson, K.J., Gachon, P., Vico, L., Bernard, J.J., Alexandre, C., et al. (1998). Energy and substrate metabolism during a 42-day bed-rest in a head-down tilt position in humans. European Journal of Applied Physiology; 78: 308–314.
21. Šimunič, B., Rittweger, J., Cankar, G., Jurdana, M., Volmut, T., Šetina, T., Mekjavić, I.B., Pišot, R. (2008). Odziv sestave telesa, mišične togosti in ravnotežja po 35-dnevni odsotnosti gibanja pri mladih in zdravih preiskovancih. Zdravstveno Varstvo; 47(2): 60–71.