



EFFECT OF A 14-DAY BED REST WITH RECOVERY ON MUSCLE CHARACTERISTICS OF YOUNG AND OLDER ADULTS

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Abstract — Skeletal muscle is very adaptable and has a fast response to various developmental effects (growth, exercise, lifestyle, injury, illness, etc.). Influences from the environment (altitude, temperature, gravity, etc.) also affect skeletal muscle characteristics. In addition, skeletal muscle loses the flexibility and weight as well as its function with age, as long as it is not used enough. If the muscle is not exposed to regular or high physical stress (such as: inactive life or sedentary lifestyle, hospitalization – bed rest, immobilization, flight to space, etc.) can occur loss of muscle tone and volume – muscle atrophy. This area is now rapidly gaining in importance, because of the aging of the population, sedentary lifestyle and ultimately travelling to space (microgravity). To confront and understand the adjustments in this kind of environment we have to simulate these environments with horizontal bed rest. Many older individuals decline functionally during hospitalization, and the deleterious consequences of bed rest may be one cause. This study reports on the effect of 14-days of bed rest on muscle parameters in healthy young and older adults. Healthy young (N=7) and older adults (N=12) remained on bed rest for 14 days continuously followed by recovery. Measures of muscle characteristics were measured before and after bed rest and also after recovery. In healthy older adults, 14 days of bed rest results in loss of muscle fibre and whole muscle characteristics. Identification of interventions to maintain muscle function during hospitalization or periods of bed rest in older adults should be a high priority.

Index Terms — PANGeA, bed rest, ageing, muscle, muscle fiber, muscle contraction

1 BACKGROUND

Bed rest, a microgravity simulated model, is as a reliable simulation model for the most physiological effects of Spaceflight. However, reduced skeletal muscle contractile activity, as a result of bed rest, is often the cause of different diseases: cardiovascular, respiratory, circulatory and metabolic, so we could apply this model also in the field of health research.

2 OBJECTIVES

The present study was designed to evaluate the effect of 14-day bed rest and subsequent functional recovery (14 days) on older adults and compare those effects on younger adults.

3 APPROACH & METHODS

General approach

Using short term horizontal bed rest (14 days) we provoked an accelerated decline of human organism. This presentation is focused on skeletal muscle biomechanics as whole and in single fibre level.

Methods

Altogether 23 participants (7 young and 16 older) were included in the study. Muscle mass was evaluated in single fibres, and whole muscle level. Furthermore, functional tests were performed for motor abilities, gait and cognitive skills.

4 RESULTS

		BDC	BR14
diam (μm)	Young	93.5 \pm 18.4	87.1 \pm 30.2
	Older	83.8 \pm 10.1	77.8 \pm 9.1
CSA (μm^2)	Young	7266 \pm 2962	6698 \pm 5342
	Older	5793 \pm 1383	4975 \pm 1123
force (mN)	Young	1.13 \pm 0.56	1.01 \pm 0.47
	Older	0.80 \pm 0.27	0.82 \pm 0.30
tension (mN/ μm^2)	Young	121.4 \pm 44.5	138.4 \pm 51.9
	Older	119.3 \pm 59.6	138.8 \pm 46.2

Table 1: Muscle fibers characteristics

		BDC	BR14	REC14
VL pennation angle (deg)	young	16.7 ± 2.1	16.3 ± 3.1	16.6 ± 3.2
	older	16.0 ± 1.1	13.9 ± 1.2	14.7 ± 1.4
VL muscle thickness (cm)	young	2.23 ± 0.35	2.05 ± 0.34	2.15 ± 0.25
	older	2.04 ± 0.26	1.91 ± 0.24	2.10 ± 0.38
VL fascicle length	young	7.77 ± 0.83	7.36 ± 0.78	7.60 ± 0.54
	older	7.34 ± 1.05	8.08 ± 1.15	8.03 ± 1.21
MVC quadriceps (Nm)	young	681 ± 115	624 ± 41	665 ± 85
	older	530 ± 101	476 ± 109	548 ± 137
MRI quadriceps (cm ³)	young	1988 ± 270	1867 ± 204	1954 ± 211
	older	1666 ± 234	1525 ± 211	1615 ± 188

Table 2: Whole muscle characteristics

5 POTENTIAL NEW PRODUCTS & SERVICES

Product:

The upgrade of rehabilitation protocols after major surgeries (Hip, Knee, Spine, etc.)
 New knowledge about survival in Space for older adults – our study was the first of a kind.

Service:

New methodology we proposed for assessing electromechanical efficiency of skeletal muscles (based on tensio- and electro-myography)

6 CURRENT COLLABORATIONS

6.1 With other researchers

Neuroscientists, muscle physiologists (TRL0-4), Bioengineering company (TRL3 -5), Space agencies (TRL5-9), Health sector (TRL5-9).
 University of Udine, University of Trieste, University of Padova, University of Ferrara, National Institute of Public Health RS, General Hospital Izola, city communities Koper, Kranj, Ferrara

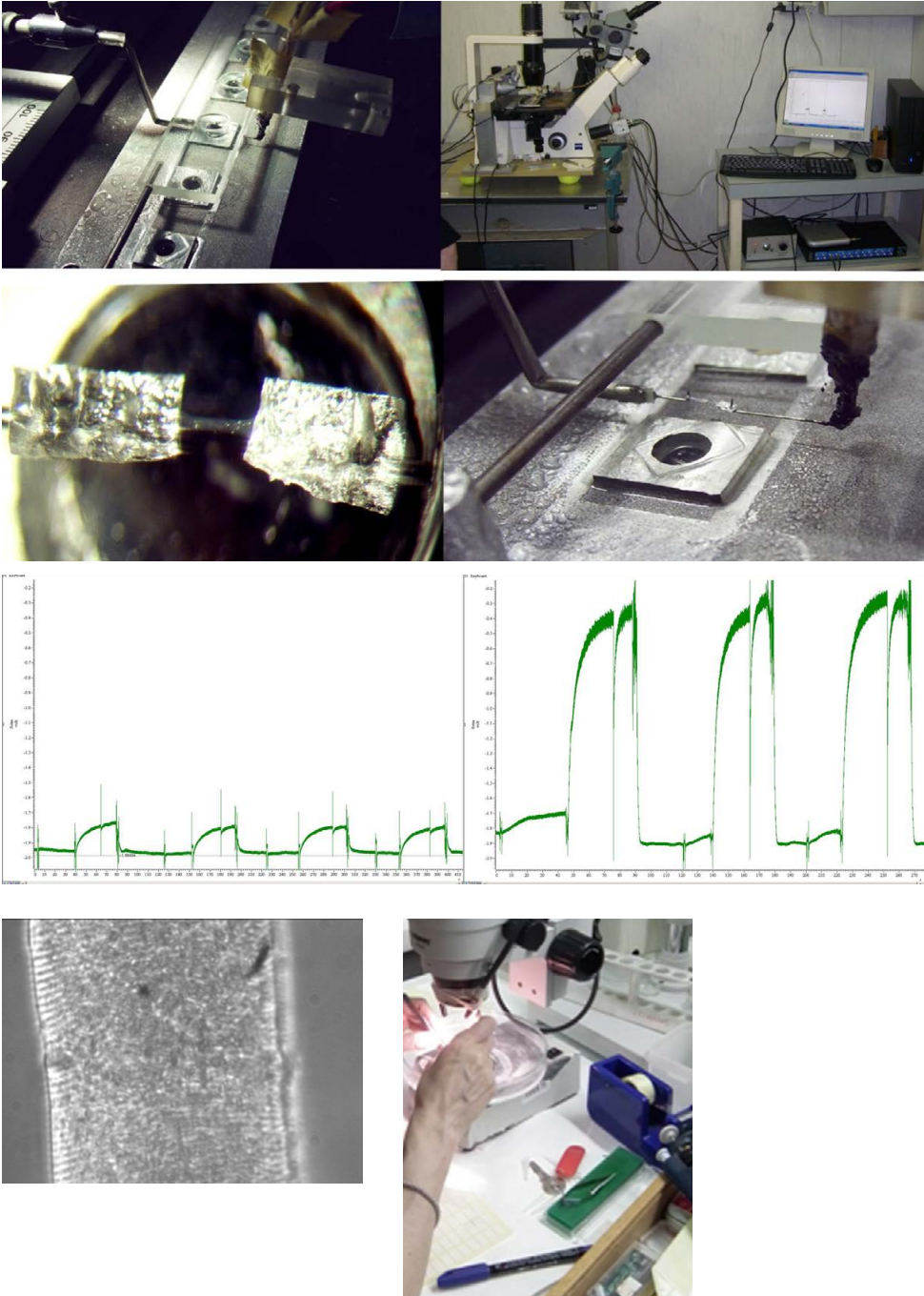


Figure 1, 2, 3 and 4: Analysis of different muscle fiber contractions in the laboratory of the Department of Human Anatomy and Physiology at the University of Padova.

7 CONTACT OR COLLABORATIONS NEEDED

We seek for collaboration for highspeed camera recording of a muscle fiber contraction.

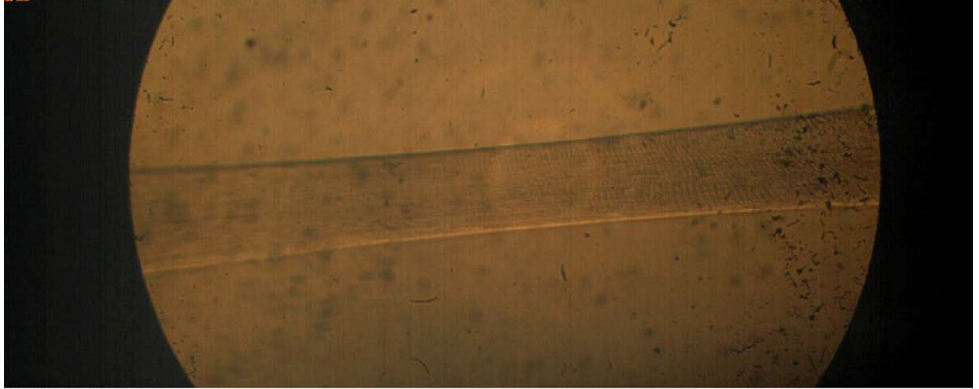


Figure 5: High speed frame of the video of a muscle fiber contraction.

For more information, please do not hesitate to contact us:

Project leader: prof. dr. Rado Pišot, email: rado.pisot@zrs.upr.si

Project administrator: dr. Suzana Todorovič, email: suzana.todorovic@zrs.upr.si

8 COMMUNICATION TOOLS

The high level of expertise in the field of bed rest is disseminated through the high quality scientific publications.

ŠIMUNIČ B., DEGENS H., RITTWEGER J., NARICI M., MEKJAVIĆ I.B., PIŠOT R. (2011). Noninvasive estimation of myosin heavy chain composition in human skeletal muscle. *Med Sci Sport Exer*, 43(9), 1619-25.

PIŠOT R., NARICI M., ŠIMUNIČ B., DE BOER M.D., SEYNNES O., JURDANA M., BIOLO G., MEKJAVIĆ I.B. (2008). Whole muscle contractile parameters and thickness loss during 35-day bed rest. *Eur J Appl Physiol*, 104(2), 409-14.

BIOLO G., AGOSTINI F. ŠIMUNIČ B., STURMA M., TORELLI L., PREISER J.C., DEBY-DUPONT G., MAGNI P., STROLLO F., PRAMPERO P., GUARNIERI G., MEKJAVIĆ I.B., PIŠOT R., NARICI M. (2008). Positive energy balance is associated with accelerated muscle atrophy and increased erythrocyte glutathione turnover during 5 wk of bed rest. *Amer J Clin Nutr*, 88(4), 950-8.

9 FUNDS NEEDED

9.1 For basic research (testing protocols to reverse degradation after bed rest): 1.200.000 €

9.2 For basic research (sensor testing, parameter identification): 500.000 €

9.3 For applied research (sensor development for real-world problems): 250.000 €

10 CONCLUSION

Our research opens new frontiers in clinical and pre-clinical investigations of muscle physiology. Additional means of maintaining muscle function during and after bed rest in older adults, including different exercise and also nutritional or pharmacological interventions, should be vigorously pursued.

ACKNOWLEDGEMENT

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