Conference Proceeding Issue Published in International Journal of Trend in Research and Development (IJTRD), ISSN: 2394-9333, www.ijtrd.com

The Training and Body Strenghtening Equipment for Trunk Muscles for People with Lower Back Pain

[1]Šooš Ľubomír, [2]Cepková Alena and [3]Uvaček Marian,
[1,2,3]Faculty of Mechanical Engineering STU in Bratislava, Nám. Slobody 17, 812 31 Bratislava, Slovakia

Abstract: unilaterally or excessive spine loading in sport, or in turn, weakness of paravertebral muscles as a result of a sedentary lifestyle often leads to functional back pain. This constitutes a medical problem with deep socioeconomic consequences. Insufficient strength of core muscles was shown as a main etiological factor. From therapeutic as well as preventive point of view, it would be very useful the device that allow full strengthening of these muscles.

Therefore we realize new very interesting project. Goal of project will be to development a new design split-core trainer strengthening system for athletes and untrained individuals with functional back pain. This process contain mainly, analyse of existing similar systems, the construction of the new design this equipment, production of prototype, and the last the testing of its technological and functional properties. In this year we have get utility model application no. SK 7147.

Afterwards, the methodology of exercises strengthening the core muscles will be proposed, and the loading on this device will be specified. Aim of paper is describe methodology of development and design Split-Core Trainer Strengthening System.

Index Terms—*Body Strengthening, Development, New Design, Split-Core Trainer*

I. INTRODUCTION

At this time there exist on the market a whole range of exercise equipment that enable individual muscles and limbs in various combinations, [1], [2], [3], [4]. However these devices do not allow directive strengthening and monitoring of a body system for sports people and untrained individuals with functional back pains. On the basis of a performed analysis of existing equipment and the state of the technology we can reliably state that at the present time a mobile modular device for body strengthening system for sports people and untrained individuals is not available.

Accordingly there arose the demand to create such equipment that will enable a functional diagnostics for spinal stability and body muscle strength. At training facilities we submitted a utility model application and a patent application. At this time the collective of authors: Šooš, Zemková, Cepková, Štefanka and Jeleň have been granted utility model no. 7147 with the title: "Variable diagnostic and/or strengthening training and/or rehabilitation equipment for body muscles" [5] and we also expect the granting of a patent within a short time.

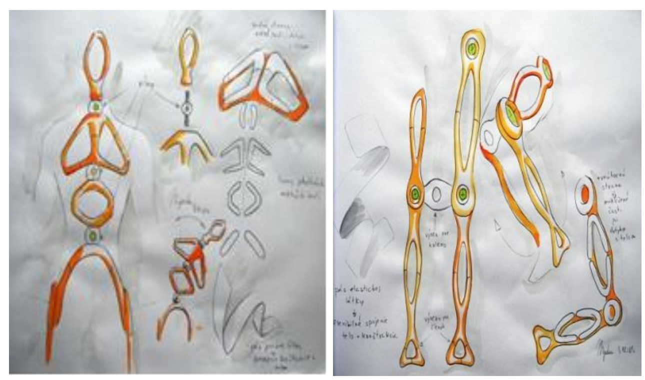
The goal of the presented article is to introduce to you the principle and elaboration stage of this strengthening equipment.

II. ANALYSIS OF THE CURRENT STATE

We also included teachers and students of the Faculty of Architecture of the Slovak University of Technology in Bratislava in the resolution of this part of the task. Under the coordination of prof. Paliatka the students designed within their annual project several ergonomic resolutions of a strengthening system. Three joint projects with the participation of elaborators from from FTVŠ UK and SjF STU in BA were submitted for the stated task. The achieved results of the students are depicted in the following figures:

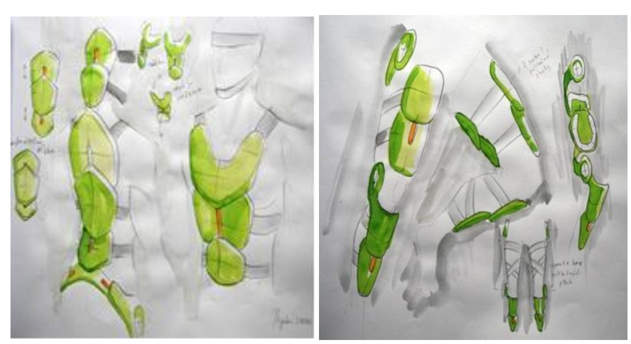
Variant no.1

Two-part system of joints



Variant no.2

Scale construction



Variant no.3

Pulley

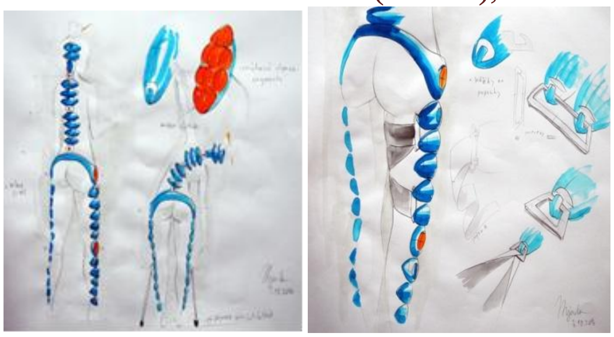


Fig. 1 Graphic studies of the resolution of a strengthening system

The students worked these projects out to the actual models illustrated in Fig. 2.

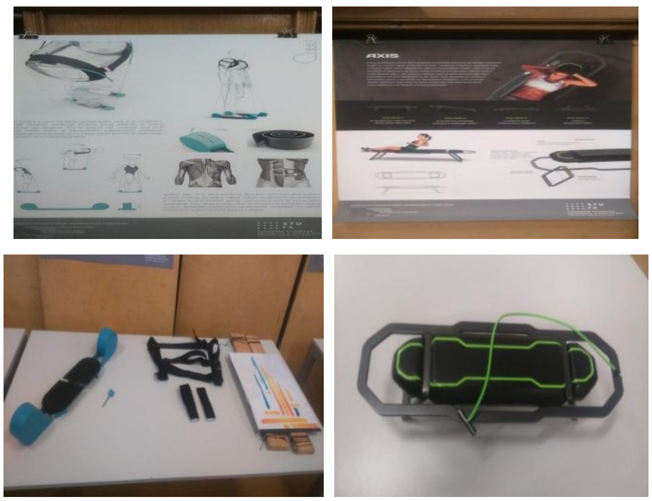


Fig. 2 Actual working out of parts of the designed graphic systems

III. DESCRIPTION OF THE EQUIPMENT

Already in the utility model name [5] “Variable diagnostic and/or strengthening training and/or rehabilitation equipment for body muscles” it refers to modular devices of a body strengthening system for sports people and untrained individuals with wide possibilities of application. In figure 3 the possibilities of the proposed strengthening system are graphically illustrated. The equipment is light, portable, and easy to assemble. In the proposed system it is possible to exercise while standing, sitting or lying. In these positions the system enables exercising or strengthening the head, the neck, torso or upper limbs. The ergonomic and anthropological resolution of the strengthening system can be set at the varying heights and physical attributes of the exerciser. The equipment’s structure will be manufactured from lightweight high-strength materials. The basis of the construction will be the multi-function joints, which are adjustable for force and direction, either by touch or remote. The individual exercising programs are also designed to be set by remote through the PLM system. This permits either the exerciser or the trainer to set the work load. In the future we will be considering the monitoring and recording of data on the exercises carried out.

We have divided the whole approach into two basic directions. Construction node points of the strengthening system. The basic bearing construction will be made up of a combination of the support parts - elements made from plastic and of support parts - elements made of light-weight alloys based on aluminum, magnesium and titanium or from progressive commercially available construction materials, metal foams on a basis of aluminum, carbon and polymer composites which provide a favourable combination of construction properties.

Orientation to the stated categories of materials arises from the concept of a progressive strengthening system which should be light and at the same sufficiently firm and strong to reliably fulfill the functions – strengthening and exercising. In the selection of material for the individual elements of the specific construction design it will be necessary to identify their function, stiffness requirements, weighting, torque and pressure, ability to absorb impact energy or strength that the element must fulfill in order to work reliably. This principle is important mainly in the case that the elaborators decide to apply metal foam or composite materials.

Currently most frequently used are aluminum foams which feature a favorable combination of high strength, low weight, corrosion resistance, health harmlessness but with relatively low tensile strength. A summary of the mechanical properties of commercially available metal foams is presented in Table I.

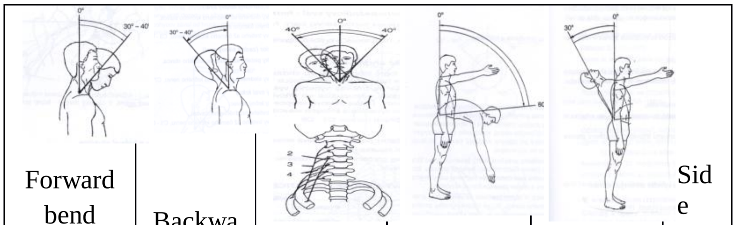
Table I. Mechanical properties of commercially available metal foams [7]

Material	**Density** (10^3 kg.m^{-3})	**Tensile strength** (GPa)	**Module of flexibility** (10^2 GPa)	**Specific strength** (10^6 GPa)	**Specific module** (10^8 GPa)
Steel	7,8	1,03	2,10	1,3	2,7
Al. alloys	2,8	0,47	0,75	1,7	2,6
Ti. alloys	4,5	0,96	1,14	2,1	2,5
Composite with fibreglass	2,0	1,06	0,40	5,3	2,0
Epoxy / carbon fiber composite II	1,45	1,50	1,40	10,3	9,7
Epoxy / carbon fiber composite I	1,6	1,07	2,40	6,7	15

Polymer composites have many advantages in comparison with metal and ceramic composites. They are ranked among progressive construction materials however due to the high specific strength, which represents the relation of strength to material density. While the strength of polymer composites on the basis of carbon fibers and epoxy resins is lower than the strength of metals, their specific strength is significantly higher than the specific strength of iron, steel, titanium or aluminum.

IV. DESCRIPTION OF THE FACILITY OF THE DEVICE

Based on the basic, we built the modular facility of device, anatomical functional movements of the human body(Figure 3).



Forward bend	Backward bend	Bow	Forward bend	Backward bend	Side body bend

Fig.3 Possibilities for strengthening the body under Utility Model no.7147

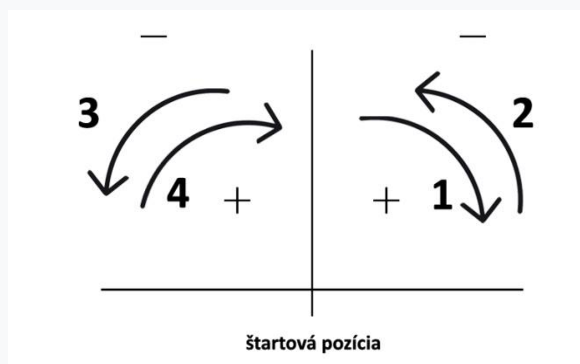
The present embodiment of the subject's devices in steering the motion in the forward backward for current angles, flexions (Fig.4) and extensions (inclination) (Fig.5). The starting position is sitting in the lumbar and knee joint of 90 °, feet the chest is fixed with a height-adjustable arm. The arms are either crossed on the breasts, on the knees, or on the sides of the chair. After preset basic exercise parameters are visual (audible signal) exercise start alert, during exercise (range of angles, reps, series) overlapping angles and end of exercise. If necessary, you have the necessary instructor at your disposal position at zero.

Fig.4 Position in flexion Fig.5 Position in extensiom

The following parameters are predefined before each exercise:
- gender
- name
- height (cm)
- weight (kg)
- Activity (Athlete, Non-Athlete)
- number of repetitions
- number of series
- rest interval (s)
- arm height (m)
- angle (range of motion called ROM) from - to (°)
- resistance (kg).

Recalculated from acquired values
- angular velocity (° / s)
- angular acceleration (m / s2)
- moment of force (even if constant) (N.m)
- mechanical power (W) "F.v"

Based on predefined values and workout on a modular device, data is exported and automatically evaluated in Excel in tabular and graphical form. They are evaluated data from each flexion and extension position, data is recorded from start position (0) to the final position (1), which was predefined by the angle also filters overlap of preset angle). From the transition from the final position (1) to the start (2) to start position (0). From start position (0) to final position (3) and from transition, that is start (4) to start position (0). Testing must be triggered manually, but the measurement itself starts automatically after the first movement into the hull flexion (1) and stops at the start position (0) after the number of preset repetitions in a given series (to avoid unnecessary) to the average values of the individual parameters).



V. PREPARATION OF THE MANUFACTURE OF A PROTOTYPE

The actual preparation of the production of the equipment goes through the planning, production and testing of the individual parts of the equipment. The functionality of the individual joints will be tested on plastic models made on 3D printers. For this reason we have already purchased plastic ABS material for the production of the individual joints. In added to joint functioning, the possibility of programming and remote controlling will be tested. At the moment we are testing the suitability, strength and functionality of the equipment's static elements. We foresee their production from foam aluminum or plastics, in a combination with carbon fibres or perhaps even from carbon.

- Preliminary production planning is completely linked to the output from the construction design, and its task is securing material and the place of production according to the technological possibilities and specifications of the proposed manufacturers,

- the output of the technology will be the precise defining of the required technological process. Together with the requirements for construction and the precision of manufacture, this will form the basis for the submission of public procurement,

- production will be the decisive and transparent part of the cooperation of the entire process of the construction resolution, strength analysis, planning and technology design.

Acknowledgment

Analyses and measurements in this test were funded from the project APVV No. APVV-15-0704. Split-Core Trainer Strengthening System for athletes and untrained individuals with functional back pain.

References

[1] http://www.glabshop.com/
[2] http://www.spinecor.com/ForProfessionals/IntroductionToSpineCor.aspx
[3] http://www.google.sk/search?q=blackroll+posture&hl=sk&gbv=2&prmd=ivns&tbm=isch&tbo=u&source=univ&sa=X&ved=0ahUKEwi28Y3z85TQAhVI1hoKHZPDBd4QsAQIGg
[4] http://www.proxomed.com/en/produktlinie/tergumed_710_-_new-42.php
[5] http://www.incorpore-tech.com/EventTool/event/75
[6] Ľ. Šooš, E. Zemková, A. Cepková, M. Štefanka, M. Jeleň, “Variable diagnostic and/or strengthening training and/or rehabilitation equipment for body muscles,” Úžitkový vzor č.7147, Banská Bystrica: Úrad priemyselného vlastníctva Slovenskej republiky , vol. 24, 2015.
[7] M.F. Ashby, A. Evans, N.A. Fleck, L.J. Gibson, J.W. Hutchinson and H.N.G. Wadley, “Metal Foams: A Design Guide. Butterworth-Heinemann,” vol. 263, 2000.
[8] Ru-Min Wang, Shui-Rong Zheng, Yujun Zheng “Polymer Matrix Composites and Technology. Woodhead Publishing,” vol. 568, 2011.
[9] T. Liptáková, P. Alexy, E. Gondár, V. Khunová, “Polymérne konštrukčné materiály,” STU: Bratislava, vol. 188, 2012.