ISBN 1392 - 1207. MECHANIKA. 2009. Nr.5(79)

Unstable simulator of academic rowing

A. Domeika*, V. Grigas, P. Žiliukas***, A. Vilkauskas******

**Kaunas University of Technology, Kestucio 27, 44312 Kaunas, Lithuania, E-mail: aurelijus.domeika@ktu.lt*
***Kaunas University of Technology, Mickeviciaus 37, 44244 Kaunas, Lithuania, E-mail: vytautas.grigas@ktu.lt*
****Kaunas University of Technology, Mickeviciaus 37, 44244 Kaunas, Lithuania, E-mail: pranas.ziliukas@ktu.lt*
*****Kaunas University of Technology, Kestucio 27, 44312 Kaunas, Lithuania, E-mail: andrius.vilkauskas@ktu.lt*

1. Introduction

The rowing is considered to be most effective for exercising maximum variety of the athlete's muscles. Thus a lot of different rowing type training facilities are used both for exercising in sports clubs and for preparing high-level sportsmen. In the simplest ones the mass of the athlete is used to generate the resisting force acting the handles simulating the oars, in more sophisticated – magnetic, inertial/pneumatic or hydraulic (including magnetorheological [1] or even smart [2] fluids) loading units are used. There are also the rowing simulators, where the professionals exercise by rowing a boat fixed in the pool (Fig. 1). In all cases one of the goals for designers was to accurately reproduce the physics of the rowing, i.e. the rowing kinematics and the pattern of resistant force. One of the major criticisms of all these machines is still the inability to train proper technique of rowing, caused by the several reasons: the variation in magnitude of the rowing force during stroke and the kinematics of movement of the athlete's body during exercise, which often have nothing common with the real rowing. And the third problem is the balance of the exercisers: all of them are designed to stand tightly on the floor, in contrast to the boat floating in the water.

The solution of the problem of kinematics of movement is offered by "Concept2" [3] and "Rowperfect" [4] (Fig. 2): "Rowperfect is the first rowing machine to accurately reproduce the physics of the rowing. Whether you are a World Championship aspirant or a non rower who just wants to get fit fast – and stay that way – the Rowperfect rowing machine represents the safest and the most effective way to get there". Indoor facilities ensuring the muscle load more corresponding the loading during the real rowing process, including variation during race, movement and positioning the handle of oar are also known (the pool shown on the Fig. 1 or cumbersome computer controlled loading units [5, 6]), but in this paper attention is paid to the balance of exerciser, i.e. seeking to give the rower the sense of "floating boat".

The idea of unstable exercising is widely used, for example, in bodybuilding [7] (usage of free weights). Unstable bicycle training facilities (Home Trainers) [8] where the bicycle stands freely by his wheels resting on rollers simulating the road and the athlete must keep balance when exercising are also known. Due to peculiarities of rowing special exercises for rowers appeared [9] and also attempts are made in developing the unbalanced training facilities for rowing. As an examples the Stability Adjustable Ergometer Seat "Core Perform CP1" (Core Perform, USA) (Fig. 3, a) [10] and a rowing simulator Rowbalance (Rowbalance, USA) (Fig. 3, b) [11] can be provided.

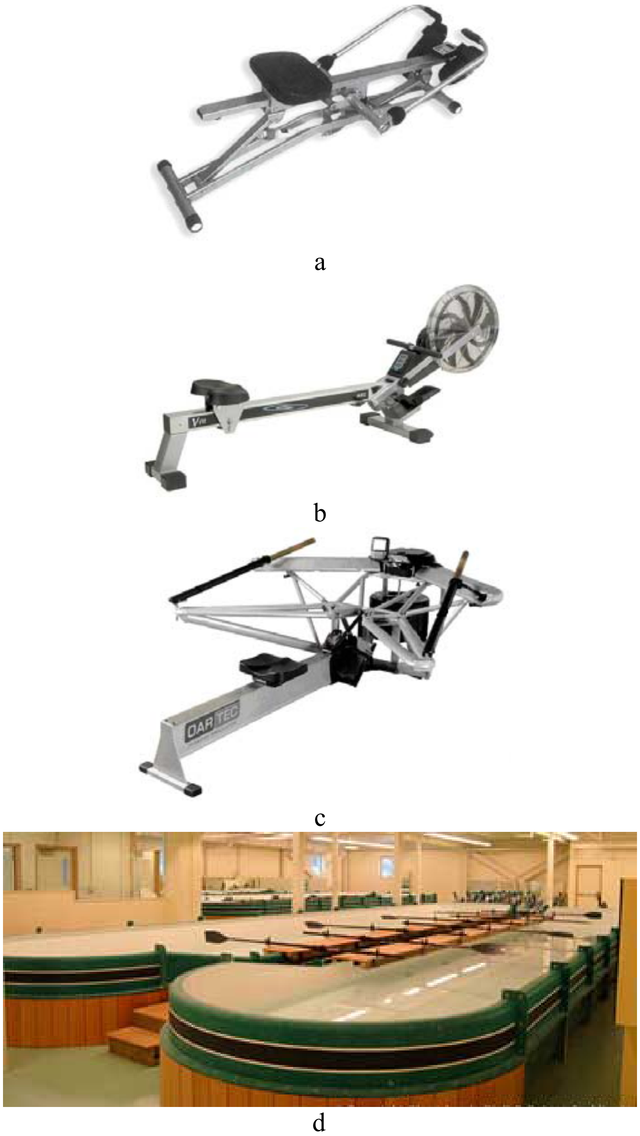


Fig. 1 Rowing exercisers of different types of generation of the resisting force: a – by the oarsman's weight; b – by the flywheel; c – by the hydraulic loading unit; d – boat in the pool

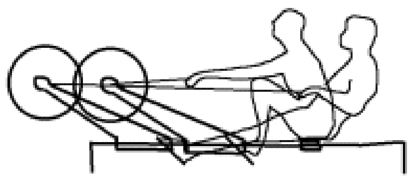


Fig. 2 Scheme of rowing exercisers „RowPerfect“ and "Concept“

a

b

Fig. 3 Unbalanced training facilities for rowing: Core Perform CP1 (a) and rowing simulator Rowbalance (b)

Both of them are some modification of the classical rowing exerciser (for example, Concept2). In first case the rowing machine is equipped with the stability adjustable rowing seat, and in a second case the whole exerciser is mounted on balancing supports, allowing the exerciser swinging about horizontal axis, parallel to its longitudinal axis. Thus the exerciser is able to swing during exercising, but the adjustable seat does not prevent helping with balancing by legs, and the equilibrium of Rowbalance is still stable, because axis of swinging is located higher than the centre of masses of athlete-exerciser system. Therefore the actual degree of oarsmen roll (side-to-side) while rowing real boat is not fully matched, because here the rower-boat equilibrium is unstable and the rower has no stable foot supports. In addition, the handle of such exercisers must be pulled by both hands a at a time, what is different from the situation when athlete must operate with two oars each affected by the different load.

The aim of this study is to present and to validate a novel indoor rowing machine – unstable balancing exerciser, demanding from athlete not only to workout, but also to keep his balance as in the boat floating in the water.

The primary problem of the ongoing development of the rowing machine loading unit is to establish what geometric parameters of the unit allow to achieve the required values of loading on the oar at different intensity of rowing. The paper presents the results of computer aided analysis of the possibilities to put the chosen method of loading into practice, and to develop the loading unit.

2. Unstable simulator of academic rowing (sculling)

The novel unstable balancing simulator of academic rowing has been designed in Engineering Mechanics department of KTU (Kaunas University of Technology, Kaunas, Lithuania) (Fig. 4). The lever type rowing simulator Rower Cobra (HAMMER Sport AG, Germany) was used for the base of simulator as giving the most adequate kinematics of oars handles movement. It was suspended on the cross-shaped basement frame via main (front and rear) and side elastic supports. Such suspension ensures the whole simulator (including feet supports) the possibility of vertical oscillations (± 20 mm) as well as swinging about two horizontal axes – transversal and longitudinal (± 2^O about transversal and ± 10^O about longitudinal axis), both being located lower than centre of masses of system rower-boat, as it lies in reality. The parameters of elastic supports were chosen after the measurements of the real boat swinging during rowing in natural conditions performed in Lampedziai Rowing sports base near Kaunas.

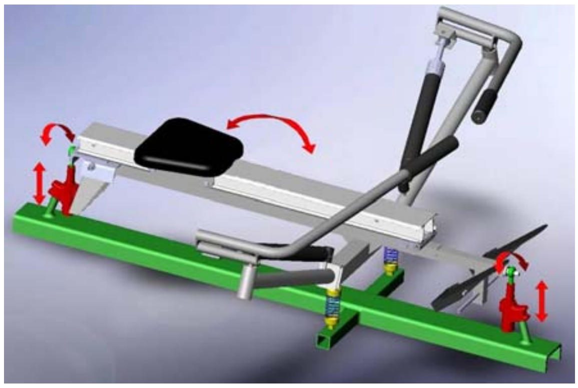


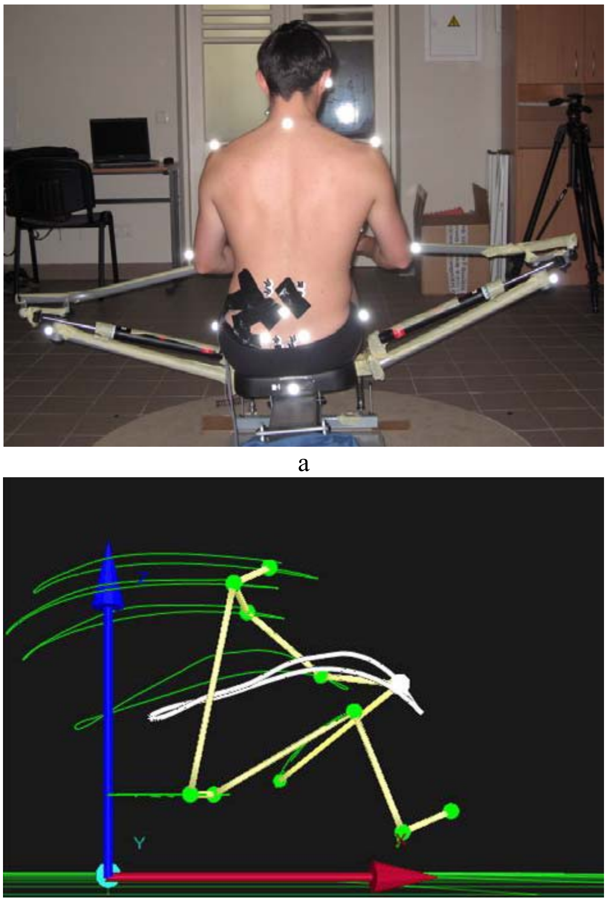
Fig. 4 Novel unstable balancing simulator of academic rowing built in KTU (computer model)

3. Analysis of motion when rowing unstable simulator

Basing on the prototype of simulator an initial research has been performed in biomechatronics laboratory of the Mechatronics Centre for Research, Studies and Information of KTU, having the aim to check the conformity of unstable balancing simulator to rowing at the natural conditions and to evaluate the influence of instability of simulator on the carriage of oarsman during exercising.

This research has been performed by means of 3D Motion Capture system Qualisys (six ProReflex MCU type 200 Hz measurement frequency video cameras and QTM software) (Fig. 5, a). The cameras recognize specific points of oarsman's body labeled by the spherical light reflective markers ant transmit synchronically information about their position to the computer, where QTM software processes the information received and builds the patterns of movement of these points. Basing on this data the simplified computer model of moving object can be built by QTM (Fig. 5, b) and the numerical data exported to further processing.

The measurements of the movements of 33 years old, 180 cm height, 75 kg weight person on stable and unstable simulator when rowing at slow, 29 cycles/min rate, and at high, 37 cycles/min, rate have been carried out. 30 cycles of rowing were recorded for all regimes of rowing. The angle of swinging of simulator about its longitudinal axis was evaluated on the basis of vertical coordinates of the markers placed on oars supports, and the carriage of oarsman was evaluated according to the patterns of movement of the 3rd neck vertebra where the marker was placed also (Fig. 5, a).



a

b

Fig. 5 Measurement of oarsman's body movement by MoCap system QUALISYS: a – object labeled with light reflective markers; b – computer model of oarsman built on QTM software

The variation of angular deviation of the unstable simulator with respect to stable horizontal position when rowing at different rate is shown in Fig. 6 (5 cycles fragments). It can be seen that the solid curve (Fig. 6), representing rowing at lower rate, is of definitely periodical character and the amplitude of swinging is smaller – about 1° than when rowing at higher rate (dotted line in Fig. 6).

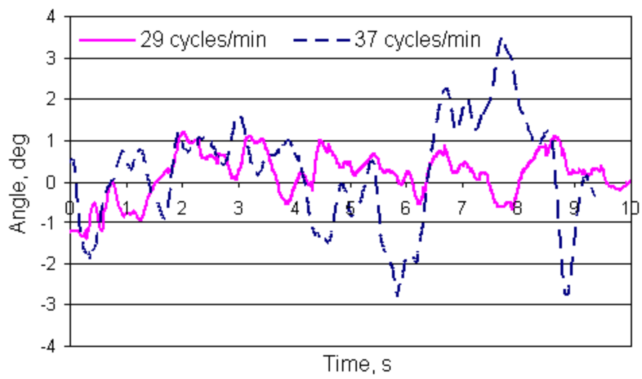


Fig. 6 Angular deviation of the simulator with respect to stable position when rowing at different rate

In the latter case keeping the balance is more difficult, because periodicity of the curve is not so obvious and the maximal angle of leaning reaches 2 - 3° , what is quite close to the situation of rowing the boat floating in the water [9].

The influence of instability on the carriage of oarsman may be seen according to the transversal displacement of the marker placed on the 3rd neck vertebra when rowing stable and unstable simulator at different rate, shown on Fig. 7 (5 cycles fragments).

On the Fig. 8 the motion patterns of this characteristic point are demonstrated in coordinates x-y, corresponding longitudinal and transversal axes of the simulator when exercising stable (Fig. 8, a) and unstable (Fig. 8, b) simulator at 29 cycles/min rate. Here the influence of instability on the carriage of oarsman during exercising also can be seen well.

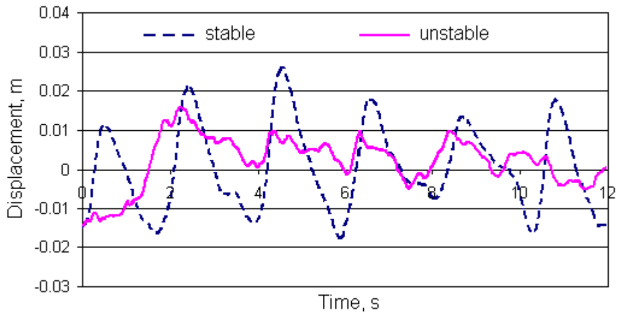
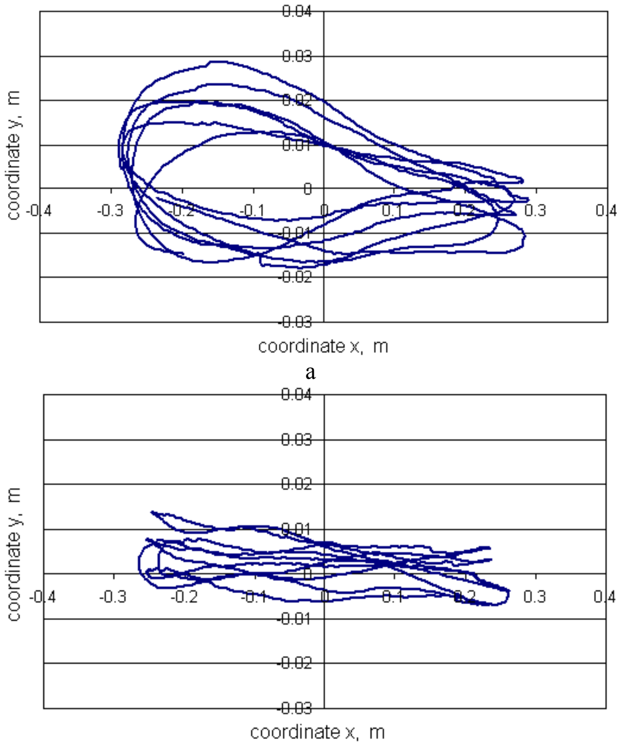


Fig. 7 Transversal displacement of the marker placed on the 3rd neck vertebra when rowing at 29 cycles/min rate



a

b

Fig. 8 Motion patterns of the marker placed on the 3rd neck vertebra when rowing at 29 cycles/min rate: a – stable simulator; b – unstable simulator

It can be seen from Figs. 7 and 8, a, that when exercising on stable simulator the transversal displacement of the marker placed on the 3rd neck vertebra draws quite regular curve of periodical character again. It was obtained that independently on the rate of rowing its amplitude measures 25 mm.

The situation is different when the simulator is set to unstable. The athlete must keep balance of the system, so the amplitude of transversal displacement of the marker placed on the 3rd neck vertebra becomes smaller more than 2 times – it reduces up to 10 mm at 29 cycles/min rate (Fig. 8, b). That means that the oarsman concentrates not only on maintaining the rate of rowing but also on balancing, which demands better coordination of movements. The muscles activity should also be different when rowing unstable simulator.

When rowing at maximal rate the amplitude of the transversal displacement of 3rd neck vertebra was find slightly larger, what means that the keeping the balance when exercising on unstable simulator more intensively is more complicated. This can be explained by the fact that when rowing real boat it is under additional stabilizing effected by the hydrodynamic effect of water on the boat hull and by the inertia of athlete body moving linearly along the path of the race.

4. Conclusions

The unstable balancing simulator of academic rowing has been designed in Engineering Mechanics department of KTU. The experimental research was carried out having the aim to check the conformity of this simulator to rowing at the natural conditions and to evaluate the influence of instability of simulator on the carriage of oarsman during exercising.

It was obtained that the angular deviation of the unstable simulator with respect to stable horizontal position when rowing at different rate corresponds the rowing the boat floating in water – amplitude of swinging is about 2 – 3°. Also the influence of instability of simulator on oarsman's carriage was established, allowing to propose that the designed rowing machine gives more adequate sense of rowing and allows to train rowing technique and coordination of movements more efficiently than conventional stable rowing exercisers.

References

1. **Bansevičius, R., Zhurauski, M., Dragašius, E., Chodočinskas, S.J.** Destruction of chains in magnetorheological fluids by high frequency oscillation.-Mechanika. -Kaunas: Technologija, 2008, Nr.5(73), p.23-26.
2. **Zhurauski, M., Dragašius, E., Korobko, E., Novikova, Z.** Mechanical properties of smart fluids under combined electrical and magnetic fields.-Mechanika. -Kaunas: Technologija, 2008, Nr.6(74), p.21-24.
3. http://www.concept2.com/us/default.asp.
4. http://www.rowperfect.com.au/.
5. **Grigas, V., Domeika, A., Legha, A., Satkunskiene, D., Tolocka, R.T.** Rowing force and its simulation on training facility.-Solid State Phenomena: Mechatronics Systems and Materials III. Uetikon-Zuerich: Trans Tech Publications Ltd. ISSN 1012-0394, 2009, v.147-149, p.712-715.
6. **Grigas V., Legha A., Toločka R.T.** Simulation possibilities of controlled rowing force generated by hydraulic loading unit of training facility.-Mechanika. -Kaunas: Technologija, 2009, Nr.2(76), p.65-68.
7. **Zatsiorsky, V.M.** Science and Practice of Strength Training. -Human Kinetics, 1995.-243p.
8. http://www.cyclesetsports.com/boutique_en_article_1058.html
9. http://home.hia.no/~stephens/rowstre.htm.
10. http://www.coreperform.com/product.php.
11. http://www.rowbalance.com/.

A. Domeika, V. Grigas., P. Žiliukas, A. Vilkauskas

NEPUSIAUSVIRAS AKADEMINIO IRKLAVIMO TRENIRUOKLIS

R e z i u m ė

Sukurtas originalus nepusiausviras treniruoklis – akademinio irklavimo imitatorius. Naudojantis erdvinio judesių matavimo ir analizės sistema „Qualisys“ atlikti treniruoklio svyravimų bei irkluotojo laikysenos, irkluojant pusiausviru ir nepusiausviru treniruokliais, lyginamieji matavimai atliekant pratimus skirtingu tempu. Remiantis matavimų rezultatais parodyta, jog mankštinimasis nepusiausviru treniruokliu labiau atitinka realios akademinės valties irklavimą.

A. Domeika, V. Grigas., P. Žiliukas, A. Vilkauskas

UNSTABLE SIMULATOR OF ACADEMIC ROWING

S u m m a r y

The paper presents the novel unstable balancing simulator of academic rowing. The results of measurements of swinging of the simulator and the bearing of oarsman when rowing simulator at stable and unstable regimes at different rates by means of 3D Motion Capture system Qualisys are provided. Basing on the results of research the conclusions about the ability of unstable simulator to give the athlete more adequate sense of rowing are withdrawn.

А. Домейка, В. Григас, П. Жилюкас, А. Вилкаускас

НЕУСТОЙЧИВЫЙ ТРЕНАЖЕР АКАДЕМИЧЕСКОЙ ГРЕБЛИ

Р е з ю м е

Представлен новый тренажер академической гребли с неустойчивым равновесием. Показаны результаты измерений покачивания тренажера и поведения гребца при упражнениях на тренажере в устойчивом и неустойчивом режимах с различной интенсивностью посредством трехмерной системы измерений и анализа движений Qualisys. На основе результатов исследования показано, что тренажер с неустойчивым равновесием более адекватно имитирует академическую греблю.

Received July 02, 2009
Accepted September 15, 2009