

# HUMAN BALANCE FUNCTION DIAGNOSTIC AND IMPROVEMENT MODEL WITHIN SOCIAL TELEREHABILITATION SYSTEM

*Aleksandrs Gorbunovs, Atis Kapenieks*

*Riga Technical University, Riga, Latvia*

*Velta Lubkina*

*Rezekne Academy of Technologies, Rezekne, Latvia*

## **Abstract**

Very often persons with disabilities are faced with several obstacles such as lower level of services, limitations and inadequate access to education, health care, information and communication technology resources, unsuitable buildings entrance and workplaces equipment. Existing e-health models are rather general. The aim of this paper is to propose new social telerehabilitation system supportive human balance function diagnostic and improvement model which would enhance inclusion process.

**Keywords:** *balance disorders; inclusive education; health promotion; telerehabilitation.*

## **Introduction**

In 2011 The World Bank (WB) and World Health Organization (WHO) made the first ever world report on disability. The report has made important contribution to the international discourse on disability and development. The statistical data show that 15 per cent of the world population subsist with some form of disability, and about one-fifth of them have severe disability types (World Health Organization, 2011; Officer & Posarac, et al, 2011). Unfortunately, very often these persons are faced with several obstacles in their residence countries, which includes barriers such as lower level of services for persons with special needs, limitations and inadequate access to education and health care, as well information and communication technology resources, unsuitable buildings entrance and workplaces equipment, which cause unsafe working conditions, and so on. World report on disability also concludes that people with disabilities have poorer health and worse socioeconomic outcomes than people without disabilities (The World Bank, 2011).

The United Nations (UN) has worked out several policy documents which urge countries to take necessary steps for eliminating inequalities between different people and groups. In 2012 the UN announced an integration of people with special needs in all society activities as its strategic course of action (The United Nations, 2006; UN General Assembly, 2012). Two year later the UN Economic and Social Council issued the Resolution which was targeted

against any barriers which would be raised during engaging of persons with special needs in society activities and their employment with respect to equal rights for everybody (UN Economic and Social Council, 2014). Continuing this strategic course of action, the UN has developed “2030 Agenda for Sustainable Development” goals which promote and guarantee equal and accessible education through creating and development of appropriate inclusive learning environments, effective preparation for employment, fully access to job market without any restrictions and barriers (The United Nations, 2015).

The WB’s last update on the World report on disability, which covers 193 countries, shows that in an average 9,3 years of health are lost due to disability (The World Bank, 2013). This number is too big as it means also big losses for countries’ economies. The world countries are urged to implement UN Resolutions as well as WB and WHO recommendations regarding full integration of persons with disabilities in society. Countries ought to take steps in order to improve quality of life of people with disabilities, accordingly facilitating inclusion and development processes and improving their participation in society activities. Governments and municipalities ought to promote also persons with disabilities reintegration measures into various professions and businesses (Oortwijn et al., 2011).

At the end of the year 2016 the Council of the European Union (EU) has issued the Directive on the accessibility of the websites and mobile applications of public sector bodies (Council of the European Union, 2016). It sets out accessibility requirements for the websites and mobile applications of public sector bodies. The Directive will facilitate people’s with disabilities and elderly people’s access to data and services on the Internet, for example, to make payments, submit a tax return in order to apply for the benefits, or enter university.

Governors, subject matter experts and researchers develop appropriate models which are aimed to make more effective social inclusion and sustainability processes. Although modern approaches unfold many and many e-medicine or e-health models, in majority they are rather general and not so specified to solve particular issues related to balance function diagnostic and improvement. Due to that the aim of this paper is to propose new tele-rehabilitation system supportive balance function diagnostic and improvement model, which would enhance people’s inclusion into society through improvement of their postural control skills, respectively – physical health and socio-functional capability.

## **Methodology**

### ***Social (tele)rehabilitation and public health domain***

Some common challenges for different regions which influence the successful implementation of principles in social inclusion of people of the vulnerable social target groups could be specified:

- High level of social exclusion, poverty and unemployment;
- Limited accessibility to the e-services and data on the web and mobile applications which leads to the exclusion of some groups of people from society and establishes serious obstacles in people’s inclusion;
- Insufficient collaboration in social field between different field organizations providing similar services;
- Lack of scientifically and practically based models of collaboration in networks;
- Necessity for the new approaches and alternative social inclusion technologies in social services in a complementary manner across the states’ and regions’ borders to ensure their better accessibility and efficiency to target groups.

Social rehabilitation, together with medicine, care and public health directions, is an integral part of rehabilitation system. Thanks to modern technologies, all these fields have been obtaining the prefix “e” or “tele”, pointing their more powerful and efficacious capacities to reach the target group by enabling delivery of rehabilitation services over cyberspace, mobile and television communication networks. Digital component becomes an important part of telerehabilitation services directed to improve the quality of people’s life (Markovitch et al., 2013). In this paper we pay heed to the social rehabilitation, and particularly, social telerehabilitation domain which is aimed to improve the socio-functional capability of people and their inclusion into society, accordingly conquering its significant place within the whole rehabilitation model (Lubkina & Marzano, 2015).

These considerations point out several fields of activities which are tailored to satisfy common social rehabilitation goals, such as practical assistance in rehabilitation which goes beyond social care measures and includes diagnostics and functional capacity determination; various complexes of physical rehabilitation exercises; treatments; social inclusion measures including collaborating and knowledge sharing activities; workforce retaining, competence framework and lifelong learning enhancement challenges, and many others. Further in this paper we provide an insight in particular social rehabilitation areas which would impact proposed social telerehabilitation system supportive balance function diagnostic and improvement model the most.

#### ***The field of balance function determination and physical rehabilitation exercises***

People’s habits, as a partial indicator, and their inability to fulfil some functions (people with disabilities), as an objective one, affect their health condition and functional capabilities. Bad habits or disability caused limitations lead to decrease of life quality (Kaupuzs & Usca, 2014). Especially it has an impact in childhood and school years. Research results show significant problems of postural stability of teenagers (Kaupuzs & Larins, 2015).

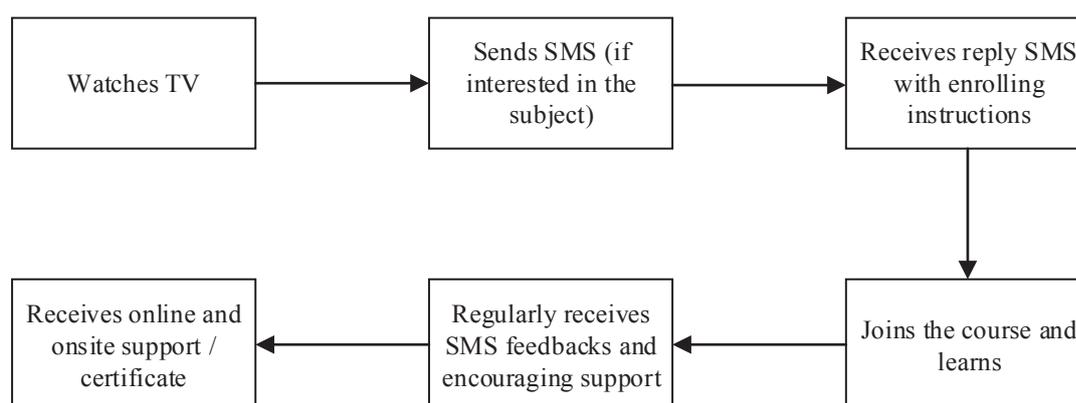
To identify persons with vestibular disorders, clinicians use several balance tests, for example, Berg Balance Scale (Berg), Dynamic Gait Index (DGI), Timed Up and Go (TUG), Computerized Dynamic Posturography Sensory Organization Test (SOT), Functional Mobility Test (FMT or obstacle avoidance test), etc. (Cohen & Kimball, 2008). Recent findings, including results obtained by Delphi research method, indicate that the Clinical Test of Sensory Organization and Balance (CTSIB) is one of the most widely used tests of balance function determination (Murray, Salvatore, Powell, & Reed-Jones, 2014).

CTSIB test allows deduction of person’s balance disorders by asking the patient to fulfil 6 balance keeping tests in different conditions: once standing on a stable platform with eyes open, then – eyes closed, then – sway-referenced vision, and thereupon at the second time – the same procedures standing on a foam platform. CTSIB test’s modified version mCTSIB excludes sway-referenced vision test mode on both stable and foam surfaces, accordingly forming 4 test modes. Many and many clinical tests and studies demonstrated mCTSIB test’s rather simplicity, confident usefulness and ability quickly and efficiently determine patient’s balance disorder (Park et al., 2013; Kaupuzs, Larins, & Rizakova, 2016).

Necessary rehabilitation exercises might be fulfilled by using of various types of balance function training systems, mobile applications and gadgets available on the market. Development of video-based training materials, supported also by mobile applications, would be excellent option for the patients willing to improve own balance function capability.

### *The field of technology enhanced and lifelong learning*

The lifelong learning challenge is considered as the one of key drivers, supporting social inclusion, sustainability and prosperity (Volles, 2016). It is concluded that advanced distributed learning technologies stimulate learning process (Kirkwood & Price, 2014). However, not all of modern technologies address accessibility needs in regards to the Article 9 and its paragraphs (f), (g) and (h) of the UN Convention on the Rights of Persons with Disabilities (The United Nations, 2006). In EU this problem will be noticeably reduced by implementing of noted before EU Directive on the accessibility of the websites and mobile applications (Council of the European Union, 2016). The Directive also impacts other world countries: both importers from EU, which will receive appropriate products and services, and exporters to EU, which will be forced to adjust their technological devices to EU requirements.



**Fig. 1.** Learner's activities in multi-screen learning environment

Innovative learning delivery solutions, introduced by Riga Technical University in 2013, include award winning multi-screen learning eBig3 approach (BOLDIC Award 2013 – Best eLearning Innovation in Scandinavia and Baltics) consisting of complementary merge of e-learning – mainly computer and/or internet-based learning, t-learning – TV based learning, and m-learning – learning with a use of mobile devices; to produce an effective cross-media learning delivery system, going beyond traditional web-based learning in accessibility, availability and usability (Kapenieks et al., 2014). Complementary combination of two or three learning delivery channels supports learning anywhere anytime paradigm. Learner's engagement into the course is simple. The learner (Fig. 1) during TV/video watching can simply send a short message (SMS) to the phone number displayed on the TV screen if he/she is interested in the subject. Shortly eBig3 system generates reply SMS with course joining instructions, including username and password. During the online/offline course the learner receives encouraging SMSs on the regular basis with necessary training support. Taking into account rather low level of drop-outs in such approach, as well increased number of learners in comparison with the e-learning course participation form when the users are requested to give a complete profile information at the moment of the registration to the course (e.g., pilots in Baltic countries showed the increase of more than 10 times), abovementioned multi-screen learning eBig3 approach (Gorbunovs et al., 2015) has a notable potential to be included into the new tele-rehabilitation system supportive model.

In the proposed model we would go further and embolden our target group to compose learning objects within our telerehabilitation system in their personalized order and sequence,

giving a broad range of possibilities to form own individualized learning path. At the same time the model will keep also an option for choosing of learning objects from the predefined course content list. Users learning support will be provided at all stages of knowledge acquisition process both virtually and in person by available information and communication technology tools.

Moreover, it will be extended much more behind technology enhanced learning system. It will transfer and share user support responsibilities with personnel in regional scientifically-methodological social rehabilitation centres and smart-classes, where innovative technologies are brought into the classroom to assist learners enabling communication, collaboration and sharing between learners, i.e., social target group users, and instructors, i.e., tutors, as well as social rehabilitation, public health and medical personnel (Alelaiwia et al., 2015; Jo et al., 2016).

### ***Public e-health, e-medicine and e-rehabilitation models***

Public e-health models in their variety includes e-medicine, e-pharmacy, e-rehabilitation and e-care sub-models. Moreover, e-business, e-finance, and e-governance components are also considered and embedded into or linked to the corresponding e-health model. Previous studies suggest that e-health models, realized in corresponding systems, are able to provide effectual solutions to satisfy public health, medical care and social rehabilitation needs, ensuring reliability and sustainability. To do so, they need to consider interests of potential users of such models/systems, as well organizational, social and technological aspects (Rahimi, 2007). All stakeholders are interested in getting of expediency from e-health system usage. It is underlined that appropriate e-model ought to rely on business principles and investigate relations between customers and suppliers, product and service data flow, usability and benefits for participants (Gordijn, Akkermans, & van Vliet, 2000; Gordijn, 2001).

Modern view on the introducing of e-rehabilitation models is tied with electronics, sensors, artificial intelligence and Internet of Things applications. These instruments can minimize the number of medical personnel necessary for rehabilitation procedures (Vukicevic et al., 2016). E-rehabilitation and e-care services become an important part of the whole eHealth system allowing persons with special needs remain independent or at least keep some independence, and at the same time enabling personalized care and rehabilitation processes at home (Barriga et al., 2016).

Useful solutions are suggested for information technology system developers to model and create user-centred at home displaced equipment and technology which take into account users' interests. Tasks (e.g., self-monitoring, self-care, disease management, and communication), environment (e.g., physical, social, community, public policy) and human factors as well as technological specifications are considered (Committee on the Role of Human Factors in Home Health Care, 2011). Pursuant to particularities of persons with special needs, the personalized learning becomes incredibly important to form individualized and adjustable learning/training path for them. Four main directions should be taken into account in personalized learning case: assessed individual need; adjustments and the impact of adjustments; solution-focused approach; and collaboration (Prudnikova & Bruveris, 2015).

The study, fulfilled by European Commission (EC), has identified several shortages which are crucial to put into practice eHealth business model: strong management and

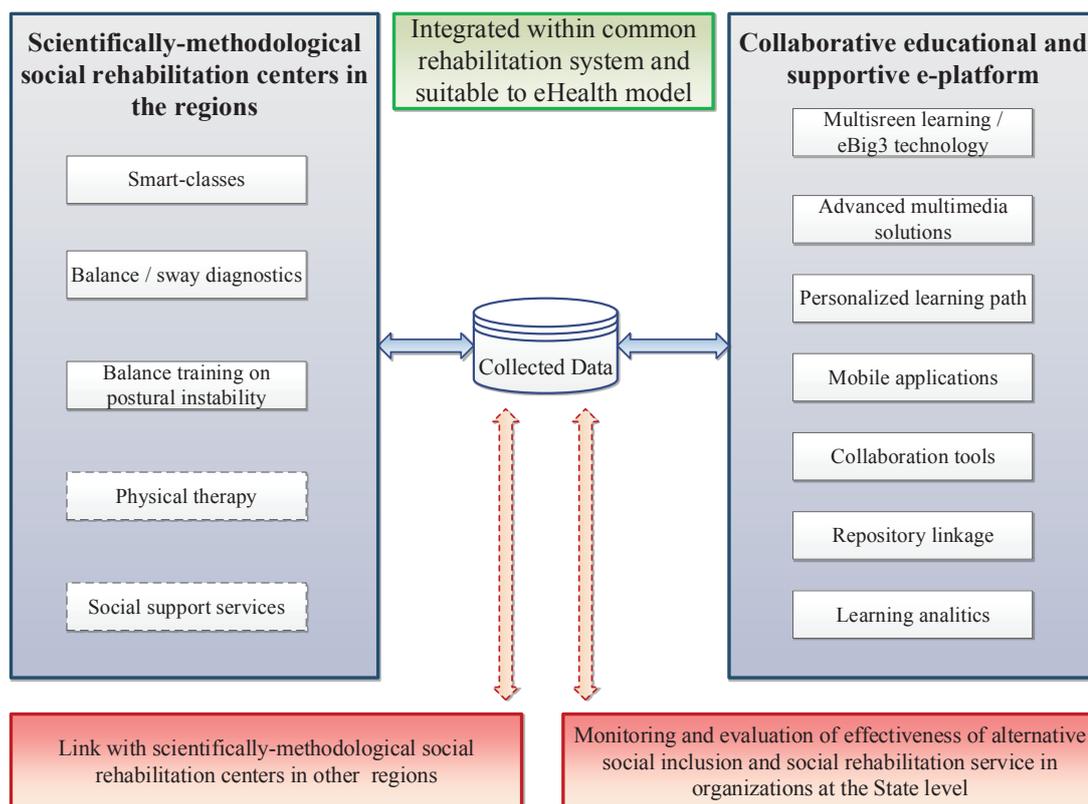
leadership, development of corresponding policy documents, pre-procurement issues, launching of pilots, sharing of good practices both in organizational and funding areas, removing technical obstacles, such as an interoperability and a lack of common medical terminology and standards (Valeri, Giesen, Jansen, & Klokgieters, 2010). In 2012 EC adopted eHealth Action Plan to maximize social and economic benefits through interoperability and the implementation of various eHealth systems. It indicates several obstacles which impede a more effective uptake of eHealth model in practice which are as follows: a lack of reliable and competent information regarding eHealth model and provided services, which causes a loss of confidence; different eHealth model solutions in different countries and even regions underline a lack of interoperability and common standards in this field; the model's implementation delays and limited number of success stories and approbated large scale pilots; personal data protection legal aspects; rather high eHealth model start-up costs; cultural awareness, a difference between countries and areas within the same country, depressive regions (European Commission, 2012). Although this document and study reports indicate noteworthy benefits of eHealth models and wide spectrum of prospective opportunities, they do not provide detailed information regarding eHealth model's all specific subdomains, covering some of them just partly. Thereby, the floor for discussions and proposing of social telerehabilitation system supportive balance function diagnostic and improvement model development is still open.

### **Results and discussions**

Recent studies, fulfilled in Latvia and Lithuania, displayed a large number of persons who have problems with their postural control and ability to move. The necessity to create, approbate and implement of new prototypes and innovative methodology (approaches, methods, techniques, ways) in social rehabilitation to render new services, which would help in balance dysfunction diagnostics and postural control function improvements for persons with special needs was emphasized. Ongoing Latvian National Research Program "Innovative solutions in social rehabilitation in Latvian schools in the context of inclusive education" investigates new ways in delivery of social rehabilitation services to a wide range of users, which include Internet, mobile and broadband communication channels, and cover social, educational and training support domains.

The model (Fig. 2), as a part of the whole telerehabilitation system, represents an aggregate composition of: social telerehabilitation methodology, alternative social inclusion approach including advanced multimedia solutions for alternative social inclusion and medical-public health services through corresponding collaborative educational and supportive e-platform, a set of balance training textual and audio/video materials, supportive multiscreen and multiplatform learning technology (eBig3); mobile application integration; enhancement of social networking; and creating of regional scientifically-methodological social rehabilitation centres (SMSRCs) and smart classes.

The model implies creation of several SMSRCs and smart-classes in regions of countries participating in this challenge. These centres could be developed within existing facilities in rehabilitation centres, hospitals and/or education organizations specialized in inclusive education. They also could be created anew. However, exploiting existing material resources and facilities and adopting them against new model requirements can reduce start-up costs.



**Fig. 2.** Human balance function diagnostic and improvement model within social telerehabilitation system

SMSRC includes smart-classes, human balance/sway diagnostics systems, balance/postural instability training equipment and rooms, physical therapy and social support services. Smart-classes provide learning and training of target group by use of the newest technologies as much as possible. They ensure free access to knowledge fulfilment in e-environment and consultations for people from social risk groups. Moreover, smart-classes could be considered as the place where public health and social service employees acquire new knowledge, methods and techniques necessary for their work with social target groups.

Human postural instability might be measured by various systems and tools, for example, balance platforms, like BioSway and similar ones, which are able to detect possible balance disorders. To do so, the noted before mCTSIB test with its 4 test modes (standing on the stable and on the foam platforms: eyes open and eyes closed) might be successfully applied. Balance training on postural instability could be fulfilled by using of Biodex or other similar equipment which help training of particular body muscle group. In addition, BioSway system also provides several balance training modes, including person's engagement in the simulative games. Other appropriate tools and mobile applications also form a list of instruments supporting balance functions training.

Physical therapy and social support, as they provide services mainly in person within SMSRC, would not be counted as the pure tele-services. Therefore, in Figure 2 (left column) they are marked with the dotted lines. Nevertheless, rehabilitation and health care personnel is in charge to provide necessary advisory support for patients in tele-mode.

An alternative social inclusion approach, including advanced multimedia solutions for alternative social inclusion and medical/public health services through corresponding collaborative educational and supportive e-platform, is applied. It is expected that the multimedia content for smart support of alternative social services should be designed and appropriate educational programs covering social direction and medical-public health direction should be developed. Balance training video materials with textual and audio support are aimed to reach the persons with different kinds of disability. Multiscreen learning technology (for example, Fig. 1) might be adopted allowing system users to form their own personalized learning path by composing multimedia learning objects in the preferred sequence or in the suggested by the system predefined set of training steps. Prepared video materials ought to be adjusted also for their use in mobile applications; file size and data transfer limitations should be taken into account. An important component of the system is the repository which contains available courses and learning objects. Learners activities within the system ought to be monitored by learning analytics tools.

Collaborative tools are integral components of this e-platform. Collaborative environment facilitates networking between system users: patients-patients, patients-rehabilitation specialists, patients-trainers/educators, rehabilitation specialists-trainers/educators. Moreover, it enables connecting to the services offered by SMSRC. The rapid increase of the number of people benefiting from social services could be ensured by establishing social service network. This model considers also development of procedures and tools for monitoring and evaluation of effectiveness of alternative social inclusion and social rehabilitation service in organizations. A necessity of well-prepared and competent mentors in all regions is obvious in order to provide learning assistance, further knowledge sharing, improving professional competences of social service providers.

The model ensures implementation of horizontal principles as follows:

- Sustainable development, enabling: (a) networking between social service providers and stakeholders in order to exchange experience and identify good practices and solutions, which require cross-organizational, cross-regional and cross-border intervention; (b) improvement of competences of specialists providing social services; (c) integration of vulnerable social groups in the educational activities and in the labour market; (d) improvement of accessibility and efficiency of social, including public health, alternative services and solutions by applying new approaches, tools and methods.
- Equal opportunity and non-discrimination will be succeed in the way that all clients form vulnerable social groups and social service providers in regions will have equal opportunities and access to cost-available, sustainable and qualitative alternative social and health services; besides, materials in e-environment will be available to all the interested, regardless the age, ethnicity and religion.
- Equality between men and women – representatives of both genders from social groups will be involved in the model's available processes, ensuring equal right, responsibility and opportunities for the use of resources, availability and use of established infrastructure, services and developed materials.

### Conclusions

Recent findings show that a lot of persons have problems with their balance functionality and postural control which trouble their ability to move. The society can and has to improve the quality of life of persons with disabilities. Proposed model is aimed to do so. The model

might be introduced as a separate set of policy rules and practical applications or embedded and implemented within various forms of existing and being in development phase e-health, e-medicine or even e-governance management models and systems.

The model enables providing of alternative social services under the framework of scientific methodological social rehabilitation centres and smart-classes that use the most recent advancements in science and technology to deliver high quality alternative social inclusion and social rehabilitation services well-suited for different regions. Proposed procedures ensure both diagnostics of balance function disorders and effective balance capability improvement measures, involving patients in the training programs which include both physical rehabilitation as well as advanced multimedia solutions and mobile applications. Proposed model also contributes for removing personal barriers to education: expenses, family responsibilities, work schedule, age, distance, time, health conditions.

Putting of this social telerehabilitation system supportive balance function diagnostic and improvement model into real life conditions at the initial phase might be compared with a big start-up project. It requires further business plan development, allocation of investment funds, preparation and adjustment of policy documents at national and international levels.

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### Summary

*Aleksandrs Gorbunovs, Atis Kapenieks, Riga Technical University, Riga, Latvia  
Velta Lubkina, Rezekne Academy of Technologies, Rezekne, Latvia*

The World Bank statistical data show that 15 per cent of the world population subsist with some form of disability, and about one-fifth of them have severe disability types. Unfortunately, very often these persons are faced with several obstacles in their residence countries, which includes barriers such as lower level of services for persons with special needs, limitations and inadequate access to education and health care, as well information and communication technology resources, unsuitable buildings entrance and workplaces equipment, which cause unsafe working conditions, and so on. The United Nations (UN) has worked out several policy documents which urge countries to take necessary steps for eliminating inequalities between different people and groups. In 2012 the UN announced an integration of people with special needs in all society activities as its strategic course of action. Two year later the UN Economic and Social Council issued the Resolution which was targeted against any barriers which would be raised during engaging of persons with special needs in society activities and their employment with respect to equal rights for everybody. Continuing this strategic course of action, the UN has developed “2030 Agenda for Sustainable Development” goals which promote and guarantee equal and accessible education through creating and development of appropriate inclusive learning

environments, effective preparation for employment, fully access to job market without restrictions and barriers.

Recent studies, fulfilled in Latvia and Lithuania, displayed a large number of persons who have problems with their postural control and ability to move. The necessity to create, approbate and implement of new prototypes and innovative methodology (approaches, methods, techniques, ways) in social rehabilitation to render new services, which would help in balance dysfunction diagnostics and postural control function improvements for persons with special needs was emphasized. Ongoing Latvian National Research Program “Innovative solutions in social rehabilitation in Latvian schools in the context of inclusive education” investigates new ways in delivery of social rehabilitation services to a wide range of users, which include Internet, mobile and broadband communication channels, and cover social, educational and training support domains.

Although modern approaches unfold many and many e-medicine or e-health models, in majority they are rather general and not so specified to solve particular issues related to balance function diagnostic and improvement. The aim of this paper is to propose new tele-rehabilitation system supportive balance function diagnostic and improvement model which would enhance people’s inclusion into society through improvement of their postural control skills, respectively – physical health and socio-functional capability. The model, as a part of the whole tele-rehabilitation system, represents an aggregate composition of: social tele-rehabilitation methodology, alternative social inclusion approach including advanced multimedia solutions for alternative social inclusion and medical-public health services through corresponding collaborative educational and supportive e-platform, a set of balance training textual and audio/video materials, supportive multiscreen and multiplatform learning technology eBig3 which was already acknowledged by BOLDIC (Scandinavian Open learning resources online) Award 2013; mobile application integration; social networking enhancement; and creating of regional scientifically-methodological social rehabilitation centres and smart classes.

Recent findings show that a lot of persons have problems with their balance functionality and postural control which trouble their ability to move. The society can and has to improve the quality of life of persons with disabilities. Proposed model is aimed to do so. The model might be introduced as a separate set of policy rules and practical applications or embedded and implemented within various forms of existing and being in development phase e-health, e-medicine or even e-governance management models and systems.

The model enables providing of alternative social services under the framework of scientific methodological social rehabilitation centres and smart-classes that use the most recent advancements in science and technology to deliver high quality alternative social inclusion and social rehabilitation services well-suited for different regions. Proposed procedures ensure both diagnostics of balance function disorders and effective balance capability improvement measures, involving patients in the training programs which include both physical rehabilitation as well as advanced multimedia solutions and mobile applications. Proposed model also contributes for removing personal barriers to education: expenses, family responsibilities, work schedule, age, distance, time, health conditions.

Putting of this social telerehabilitation system supportive balance function diagnostic and improvement model into real life conditions at the initial phase might be compared with a big start-up project. It requires further business plan development, allocation of investment funds, preparation and adjustment of policy documents at national and international levels. Proposed model ensures implementation of the following horizontal principles: sustainable development, equal opportunity and non-discrimination, equality between men and women.

**Corresponding author email:** [aleksandrs.gorbunovs\\_1@rtu.lv](mailto:aleksandrs.gorbunovs_1@rtu.lv)