THE ROLE AND USE OF FRENKEL’S EXERCISES IN REHABILITATION

ROLA I ZASTOSOWANIE ĆWICZEŃ FRENKLA W REHABILITACJI RUCHOWEJ

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SUMMARY • STRESZCZENIE

Introduction. Searching for physical exercise forms attainable for people in the physical rehabilitation process that compensate for certain neurological deficits is very often seen as a challenge. Meanwhile, the ideas of H.S. Frenkel at the end of the 19th century concerning compensatory treatment movement in tabetic ataxia fulfil this condition.

Method. In order to expose the actuality and therapeutic significance of Frenkel’s proposal concerning the treatment of tabetic ataxia by means of systematic exercise, an analysis of its basic premises has been provided in this article.

Results. Frenkel’s movement treatment programme was based on theoretical and clinical premises, as well as on practical experience. It was not only a pioneering enterprise in neurological rehabilitation, but it also referred to the fundamental theses of physical ergonomics. The simplicity and usefulness in improving human coordination allows for using Frenkel’s programme of systematic exercise with ageing people, too.

Conclusion. Frenkel’s programme of the treatment movement, in spite of its 19th century origins, remains present in physical therapy and can be used in the recreational activities with ageing people.

1 In the many years of my practical experience gained since 1989 in my work as a physical therapist with MS patients at the Clinic for Patients with MS in Kraków (operated at Kraków branch of Polish Society for Combatting Disabilities, where I am also a member of Presidium), as well as my scientific interests in the field of kinesiology, have led me to search for the original sources of Frenkel’s method concerning the treatment by means of regular exercise. The presented article is one of the results of the research I have undertaken.
Introduction

Searching for forms of moderate intensity exercise appropriate for people in physical rehabilitation who require the treatment of neurological deficits, such as disturbances in coordination resulting in the loss of the proper movement, seems to be regarded often in recent years as a challenge of patterns [1–4]. Meanwhile, in looking back at the history of the development of rehabilitation one can surprisingly note that not just the idea, but the clinical foundations, principles and concrete proposals of exercising had already been formulated by the end of the 19th century [5]. In order to justify the argument that H.S. Frenkel [6] added significant contributions to the progress of rehabilitation, I would like to underline the basic theses of the work of this author, accenting those contributions that are focused on the problem of treating by movement. What specifically inclines me to evaluate Frenkel’s work positively is the quantity and quality of the enumerated exercises that had been clearly described and analysed from the medical perspective of the late 19th century. In the last part of this article, I have cited the basic techniques of Frenkel’s exercises, as many current publications only provide the general concepts of his exercises rather than providing detailed descriptions.

The concept of the treatment by movement

Some basic information about Frenkel’s book can help in better understanding his ideas about the problems of tabetic ataxia and the ways of compensating for its results by means of systematic exercise. The book consists of 185 pages and is divided into two parts.

Part one, entitled General part [6, pp. 1–66], has an introductory character and covers areas relating to the types of tabetic ataxia, explaining coordination, defining ataxia, and indicating its aetiology. Moreover, one can find information in this part of the book on ways to examine cutaneous sensibility, a description of the sensation of passive movements at the joints, and the characteristics of voluntary muscle contraction. This set of practical clinical information provides for the understanding of the fundamentals of the diagnosis of ataxia, the symptoms of which should be tested in the standing position and during locomotion. Author’s analysis of human locomotion, evaluated in the context of someone’s walking skills (with or without support), which depend on motor abilities like power and balance (according to Frenkel, Rhomberg’s phenomenon is a symptom of the loss of balance), leads to an explanation of hypotonia. Frenkel [6, p. 34] noted in the chapter: ‘We therefore observe, besides motor ataxia in voluntary movements and static ataxia in trying to keep the balance when standing erect, a third change in the functions of the muscular system, an abnormally situated centre of gravity’. By using a concrete example, Frenkel characterizes hypotonia in tabetic patients:

If the extended limb can be raised to an angle of 60 to 100 degrees and more, as is frequently the case in tabes, then the flexors of the thigh (semitendinosus, semimembranosus and biceps muscles) must have undergone as alteration of their function, and this alteration we call hypotonia. [6, p. 39–40]

The alterations of muscular functions described by him concern the flexors of lower leg, quadriceps, adductors, the muscles of pelvis and spinal column, as well as the muscles of the hands and fingers. Finally, the problems undertaken in the first part of the book, such as the influence of hypotonia on the attitudes of the body, the use of the different diagnostic procedures in the disease, and the dependency between the loss of sensibility and ataxia, significantly shape the theory of tabetic ataxia, which highlights the role of the treatment by movement:

Every ataxic movement becomes still more ataxic as soon as its control by the eye ceases. This is an axiom to which there is no exception, and which is entirely due to loss of sensibility. The so-called Rhomberg’s sign is only one instance of this general rule. Standing is complicated feat of coordination, which must become unsafe if the sensibility of the various parts of the body becomes impaired, and deficiency thus created is not made up by ocular control. When Rhomberg’s sign is present, the sensibility of the motor apparatus or of the skin of the soles of the feet will always be found impaired. […] We shall see later that the good results obtained by the treatment of tabes by means of systematic exercises have given new support the theory, which holds that ataxia is caused by loss of sensation. These good results cannot be explained from any other point of view. [6, pp. 65–66]

Those opinions ending the first part of Frenkel’s script clearly show that although the aetiology of discussed hypotonia has its roots in the dysfunction of the nervous system, the only effective way of treating the disability and improving the functions of the human body is undertaking the regular and appropriate treatment by movement. In the second part of his work, entitled Special part, Frenkel presents the set of physical exercises, accenting their specific role in the treatment of tabetic ataxia.

Part two, entitled Special part [6, pp. 67–182], explains the importance of movement in the clinical process of therapy in the light of the core problems concerning (1) the movement practice, (2) the mechanisms of human body movements at the joints of foot, knee
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and hip (including skills like standing on one leg, bending the knees, gait patterns in healthy and tabetic subjects, walking sideways, getting up and sitting down, as well as walking up and down the stairs), (3) the conditions of the treatment, (4) the therapeutic exercises of lower and upper extremities in different body postures (also with the use of supporting apparatus) classified on the basis of compensating for the loss of coordination, (5) ataxia of the body in its pre-stage, (6) the therapy of hypotonia, (7) the treatment of the muscles of the eyeball, (8) the paresis of the muscle of the larynx and (9) the paralysis of the bladder. According to Frenkel, the therapeutic exercises suitable to each of the situations enumerated above should be applied.

Exercising

The pillars of the therapeutic system

The accurate analysis of therapy by movement professionally described in Frenkel's book seems to be based to a great degree on his own clinical experience gained from the time when he worked as a medical superintendent at the 'Freihof' sanatorium in Heiden, Switzerland. The following important basic pillars of Frenkel's therapeutic system, which refer to his practical clinical experience, can be found in the work of this author.

1) The first argument concerns understanding the conception of the practice of the treatment movement. In answering this question, Frenkel explains the mechanisms of physiological processes referring to both the economic way of learning movement and the effects obtained in each of the distinguished phases of the whole learning process:

We have seen that in order to "learn" a movement it is required that the motor stimulus be repeated, and that the attention of the mind be directed to it. At first the movement is accompanied by a more or less prominent sensation of muscular fatigue, which decreases as the movement becomes more familiar. Further, one notices at the beginning of the practice movements, which are absolutely useless, because they are quite outside the purpose for which the movements are intended; these useless movements disappear after a time. This sensation of fatigue and those useless movements show that at the beginning of the practice of new movements the work of the muscles is exaggerated, that they contract with unnecessary force, and call into play muscles which not only decrease as the movement becomes more familiar. Further, one notices at the beginning of the practice movements, which are absolutely useless, because they are quite outside the purpose for which the movements are intended; these useless movements disappear after a time. This sensation of fatigue and those useless movements show that at the beginning of the practice of new movements the work of the muscles is exaggerated, that they contract with unnecessary force, and call into play muscles which not only inexorably use with intended movement, but even impede and distort it. Hence we must conclude that under the influence of that complicated function which we call muscular practice a selection takes place of the muscles and amplitudes of contraction that are most suited for the purpose. [6, pp. 67–68]

Regardless of the issues stated by him in the text on how fascinating and perfectly organized the process of learning movement is, Frenkel stresses in the cited fragment the need for undertaking regular movement therapy.

2) The second argument emphasizes the role of knowledge in human muscle cooperation with the sensory system while performing human movement. According to Frenkel [6, p. 68] one of the fundamental [...] results of the practice of movements, therefore, is that various component parts of the group of the muscles, which form an anatomical and physiological entity become so emancipated from each other that each individual muscle becomes perfectly independent. In the description of the movement practice and its results, the author [6, p. 68] highlights the issue of coordinating the work of muscles by an intervention of a central nervous system: 'When a new combination of muscular contractions is being acquired the sensory impressions which are received from the joints and muscles of our extremities, and from the objects with which they come into contact are rearranged and eliminated, as the case can be'. The idea presented by him in the quoted paragraph above can be treated nowadays as a basic concept of sensorimotor training intended for both impaired people in order to make the movement therapy and for healthy people to enable them to participate in forms of mass sport.

3) The third argument shows how to realize in an effective way the purpose of physical therapy, when the mechanism of movements is generally known. Using the example concerning exercise in the case of blind people, Frenkel indicates the necessary repetition of each exercise while learning therapeutic techniques. As he writes [6, p. 69] [...] in reality the precision with which they perform the required movements is the result of long-continued practice by which the central nervous system has learnt to be satisfied with an oft-repeated of tactile impressions'. Furthermore, he reports that while treating people with tabetic ataxia: 'Repetition enables the central nervous system to differentiate stimuli of minute intensity; its sensibility becomes so great that often repeated slight stimuli act on it with the same force as rarer but much stronger impressions'. Finally, the author argues that besides the differences occurring between tabetic and healthy persons, the scheme of motor learning runs in both cases according to the same rules:

Theoretically, the transformation of an atactic movement into a normal movement takes place in tabetic subjects according to the same laws as the acquisition in healthy persons of a complicated movement, which acquires the differentiation of tactile impressions of minute strength. [6, p. 69]
In the quoted opinion, Frenkel clearly states that the rules of the mechanism of acquiring new movements by people are always the same; therefore, in such a case, it does not matter whether those movements are designed more for physical rehabilitation or for sports training. The differences then relate only to the actual level of functions of the human body depending on the state of its health status. Hence, Frenkel compared the effectiveness of the movement therapy in ataxia to the effectiveness of acquisition of the difficult motoric tasks by healthy people.

The process of motor learning, which is realized particularly as a part of the therapeutic programmes, always requires the choice of the essential conditions for its implementation. The crucial remarks stated by Frenkel relating to this problem will be analysed in the following subsection.

**Conditions of the movement treatment**

Frenkel enumerates and describes the conditions influencing the treatment of ataxia (points 1–5) and gives practical instructions (points 6–7) referring to the procedure of the movement therapy:

1) spinal irritation, which may 'appear at any stage of the disease' and 'shows itself in constant and dull pain and paraesthesia of varying intensity, which attacks the muscles of the back, and in some cases of the extremities also' [6, p. 94];

2) blindness – in the opinion of the author 'The optic sense is the greatest supporting factor in the movement treatment' [6, p. 94];

3) in a case of hypotonia of moderate degree, the additional resources of the movement treatment are not required, whereas hypotonia of severe degree 'especially of the knee joints may necessitate the correction of the faulty position of the joints by means of orthopaedic appliances, previous to the commencement of the exercises' [6, p. 94]

4) heart disease does not exclude the use of therapeutic movement; however, it requires 'great care with regard to the selection and duration of the exercises';

5) patient control during the treatment process, described accurately by Frenkel, should first of all be treated as a safety condition: fulfilling this will enable patients to be protected against accidents while exercising. Thus, 'The attendants must be the intelligent persons, who without touching the patient must raise in him the confident belief that the accident is absolutely impossible' and be aware that 'A very frequent accident during the exercise is the turning over of the foot which causes the patient to fall and often produces even the severe distortion of the ligaments' [6, p. 96]. In order to highlight the risk of accidents during the therapeutic process, Frenkel gives examples of selected clinical cases;

6) appropriate attire both for the women and men: 'The exercise treatment is tiring the most patients; it raises the pulse-rate and makes the patients perspire. For this reason the patients should wear light garments, which do not interfere with or obscure the movements of their limbs' [6, p. 99];

7) the practise rooms and apparatus:

The most suitable practise room and apparatus is that which allows of the simultaneous treatment of several patients. While one party exercises, the other has an opportunity to rest and watch them; thus fatigue is prevented, the heart has time to slow down, and perspiration becomes normal again. Moreover, the didactic value of seeing the various exercises being gone through by fellow-patients [...] is very great indeed [6, p. 99].

Nevertheless, Frenkel explains that the values of practising exercise in groups cannot be applied equally to the patients immobilized in bed who receive rehabilitation. Because of their diverse needs during this process, particularly in the cases of severe ataxia, the character of movement of those patients has a 'relatively exhaustive nature', while the lying position enables each patient 'to follow the instructions of the doctor with ease and attention' [6, p. 99]. According to Frenkel, in order to carry out physical therapy in the so-called practise rooms (the rooms should be the appropriate length and width and shape that allows a patient to walk freely) with the use of apparatus, the requirement primarily concerned equipping these rooms with chairs along the walls in order to allow the patients to rest. The set of apparatus consisting of a portable floor cross with handrails, floor marks like straight black stripes according to the patterns (for example, the ‘zigzag’ pattern), foot prints (shaded), and other elements should be available in public movement treatment practice; however, it is not necessary in private practice at home. Frenkel argues

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2 Those clinical cases described by Frenkel concerned a transverse fracture of the thigh close above the knee in a man aged 40 years, an enormous haematoma in tabetic subject aged 45 years, or troubles with walking in a woman aged 48 years.
In private practice single patients should be exercised in long and well-lighted corridors. These corridors should not be so narrow that the patient with outstretched arms could touch the walls because if such were the case the patient as well as the doctor would get a wrong idea of the patient’s ability to maintain his balance, which would be roughly dispelled as soon as the patient tried to repeat his exercise in a larger room. [6, p. 99]

Apart from the apparatus described above, Frenkel suggested using a set of apparatus for the re-education of the upper extremities ‘designed for the purpose of practising the more delicate coordination of the arms and hands’ [6, p. 105]. The apparatus consists of a triangular block, a perforated board, a peg board, a board with loose pegs, coloured balls suspended from a bar, round discs, and diagrams for copying.

Moving in different positions practised in groups and alone

According to Frenkel [6, p. 105], therapeutic exercises can be classified dependently based on the various functions of the affected limbs and a state of ataxia. These exercises should be considered separately for the lower limbs, the trunk and the upper limbs because of the diverse functions those parts serve for the human body. The lower extremities work chiefly during locomotion, while the upper limbs are responsible for performing ‘an enormous number of complicated movements of relatively small amplitudes’. The exercises for lower extremities had been systemized into movements practiced in the recumbent, sitting and standing positions, and while walking, too. Yet most of the exercises proposed by Frenkel for the lower limbs concerned the exercises in the recumbent position, mainly because of the possibility of eliminating the influence of gravitation and the necessity of keeping equilibrium in that position.

All 86 exercises in the lying position had been classified into 6 groups. Frenkel treats the first group of 16 therapeutic exercises in the recumbent position as the basic group. The leading movements while practising these exercises are flexion, extension, abduction, and adduction of lower extremities in knee and hip joints with the dorsiflexion of the foot accented. Although the other exercises in the recumbent position, which are grouped in the sets of exercises 17–44, 45–50, 51–54, 55–75 and 76–86, are more difficult than those from the first group, they have been designed based on the rules typical for the first group of exercises. Below are some of these rules [6, pp. 105–106]: (1) ‘the movements are to be continued until the maximum excursions are reached’; (2) ‘the heal has throughout the exercise to rest on the couch or bed, and slides over it backwards or forwards’; (3) ‘the eyes are to be kept open and should follow the movements with great attention’. Characterizing the tempo of the performed movements, Frenkel [6, p. 107] aptly notices that the tendency ‘which all patients have of making the movements rapidly must be overcome by energy and patience; the movements should be made as slowly as possible; the greater the progress made by the patient, the slower the movement will become’. He advises that none of the exercises should be repeated more than four times in order to fix the attention of the patient on the performed movement. When moving the legs, it is important that the patient to try to keep them in the vertical plane due to the tendency for lateral oscillations to often appear. In addition, it can be observed that many severe patients keep a plantar flexion in the ankle joint. Therefore, in Frenkel’s opinion, a patient should be asked at the beginning of exercises to keep the foot in dorsiflexion when moving the limb. Moreover, he [6, pp. 107–108] gives attention to the issue of keeping angles while exercising lower extremities: between the thigh and the lower leg, the thigh and the pelvis, and the thigh and the level. As opposed to healthy people where these angles are limited by ‘the residence of the ligaments capsules of the joints and the muscle tone’, in patients with locomotor ataxia the muscle tone is lost and the capsules are flaccid. Consequently, the possible range of motion in joints is much greater than normal; however, while exercising with the tabs ‘the movements must take place within the normal limits’. Another very important feature of these exercises in the recumbent position is the practice of static coordination linked with ‘the more or less prolonged fixation of the leg in the certain indicated position’ [6, p. 111]. For this reason, Frenkel suggests performing repetitions of some movements in each of the groups of lower limbs exercises with an additional pause that can be managed by either a patient or a doctor in order to obtain static coordination.

While describing the procedures of movement treatment with the tabs with extreme ataxia, Frenkel ensures that such cases require special care and attention on the part of a supervisor and a patient [6, pp. 120–121]. He explains: ‘For this purpose we employ simple contractions in single muscles of groups
of muscles, which have the same functions limiting the movements as much as possible to one joint'. Those movements had been divided into the groups of exercises referring to:

(1) the toes – systematic isolated movements 'are nevertheless very important, because in the course of tabes one often sees an develop anomalous position of the toes which consists of hyperextension of the first phalanx and hyperflexion of the second, respectively the second and third phalanges';

(2) the foot – 'Tabetic pseudo-paresis of the peronei muscles [...] emphasizes the necessity for carefully exercising the muscles, which produce the movements of the foot';

(3) the leg – 'For these exercises [...] it is important to eliminate movements in the hip joint';

(4) the thigh – 'In practising rotation [...] the medical man should be careful to avoid excessive outward rotation, on account of the pronounced hypotonic condition of the muscles which normally produce inward rotation'.

At the end of the description of lower extremity exercises in the recumbent position, Frenkel draws attention to exercises in bed with the use of special apparatus (the numbers of exercises: 89–94) and those practised with closed eyes ('sensory exercises') which enable the patient to imitate from memory with 'his other limb the position which the first limb has occupied or is still occupying' [6, p. 129]. All exercises in the lying position are fundamental in movement treatment in view of their relative ease of use by the tabes, which results in the improvement of ataxic dysfunction in this group of patients and allows them to maintain functional independence as far as possible. Hence, the next and/or parallel step in the treatment process covers exercises in the sitting posture preceding walking exercises. In the first case, Frenkel analyses the sequence of a patient movements of particular body parts and in joints when sitting down and getting up. In the second case, he recommends for his patients various forms of walking (forward, sideways, and backwards) in slow tempo with differing lengths of steps, maintaining the position of the upper extremities, controlling eye movement, and changing direction while walking, standing and walking with bent knees, and walking on the narrow boarder. Apart from the advice presented above, Frenkel instructed on how to use the apparatus (footprints, the stairs) while walking and how to practise this form of locomotion in groups. He also undertakes the problem of practising the gait in cases of severe – and severest – ataxia and explains how to use the special belts in order to help the patient to hold the upright position during the gait. At last, he proposes ways to examine for upper extremity ataxia concerning the shoulder, elbow, and wrist joints, and he indicates the treatment of those limbs, mainly with the use of the appropriate apparatus. Frenkel [6, pp. 181–182] also proposes ways of treating hypotonia of the whole body affected by ataxia connected with the treatment of the muscles of the eyeball ('paralysis of the muscles of the eyeball must be considered to be analogous to the tabetic paralysis of the other muscles of the body'), the muscles of the larynx ('the practice of breathing speaking and singing exercises, based upon the same principle as the exercises of the other muscles'), and treatment in case of paralysis of the bladder ('The treatment consists in instructing the patient to empty his bladder in regular intervals, a plan which invariably succeeds during the early stages of the disease').

**The set of Frenkel's fundamental exercises in the lying position**

In the conclusion of that subsection, it seems to be interesting to show some examples of the exercises in order to imagine how original and innovative the conception of Frenkel's therapy is in compensating for the deficits of ataxia. While performing the basic recommended exercises, a patient should assume the recumbent posture on the back on a low wedge-shaped bolster and with the head raised in such a position that the patient can watch every movement and his/her body rests at the same time. Each exercise begins with the initial and fundamental position in which 'Both lower limbs are stretched out in apposition to one another' [6, p. 106] and ends up in the starting position after the performance of the movement by a patient. The initial movement in case of each of the first eight exercises enumerated by Frenkel is flexion of one lower extremity in knee and hip joints followed by extension of that extremity in those joints leading back to the starting position of exercise. Between the first and last movements of the performed exercises the following modifications can take place: abduction and adduction of the flexed extremity (2, 4), the same movements as in the exercises 1–4 while flexing or extending the lower extremity (5–8) with a voluntary halt signalled by the doctor or patient. Similar rules relate to exercises 9–16. However,
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in these exercises both lower limbs should perform the single movement act simultaneously.

The basic exercises in the lying position in Frenkel's original citation have been revealed in Table 1 [6, pp. 106–107].

Conclusions

The advantages of the therapeutic concept proposed by Frenkel can be evaluated at least in several aspects. Apart from the essential medical results obtained by the use of this therapy, one can note that the methodological solutions realized in practice refer to the basic assumptions of physical ergonomics.

First of all, this idea seems to be pioneering in the aspect of using physical exercises in the treatment process in cases of the neurological disturbances. This idea is justified by the example in which patients with MS (multiple sclerosis) are still cured by Frenkel's exercises in the contemporary process of rehabilitation [10–12]. Secondly, the regularity, principles and ways of practising these exercises were based on theoretical premises as well as clinical experiences. Thirdly, the description of therapeutic exercises is based strictly

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1 The term ergonomics, having its ancient Greek etymology, was used for the first time in the contemporary lexicon by Polish scientist of the 19th century Wojciech Jastrzębowski in his article from the year 1857 entitled The Outline of Ergonomics, i.e. Science of Work, Based on the Truths Taken from the Natural Science, as a science about using given a man by the Creator forces and abilities, [7, 8]. The Council of IEA approved in 2000 the definition of ergonomics according to which that scientific discipline is ‘concerned with the understanding of the interactions among humans and other elements of a system, and the profession that applies theoretical principles, data and methods to design in order to optimize human well being and overall system’ [9]. In the practical way of ergonomics, organizing environments and systems to make them compatible with the needs, abilities, and limitations of people is of big importance. One of the fundamental ergonomic branches, being under this condition stated above, is physical ergonomics: accenting human characteristics (anatomical and physiological) in their relation to physical activity.
on Frenkel’s diagnosis of people with ataxia at different stages of their impairment, the documentation concerning their therapeutic needs, and his clinical observations of the effects of undertaking his exercise. Even now, as neurological patients who are involved in the process of physical therapy are revealing their own diverse movement needs and capacities, the procedure for measuring individual characteristics and designing a set of exercises suitable for an individual requires both medical knowledge and the experience of medical attendants in the field. Fourthly, the range of treatment encompasses not only physical exercises, but also the use of particular apparatus necessary for compensating for the lost functions of the disabled limbs and the whole body in ataxia. Contemporary technical branches working for medicine have been constantly developing the offer of orthopaedic and other type apparatus used in the treatment process addressed to the particular groups of patients. Fifthly, some exercises suitable for the disabled patients may also be used by healthy people in the form of light exercises aimed at improving good coordination and a proper range of motion in joints. The growing popularity of an aging generation doing exercise requires a search for the forms of physical activity tailored to the diverse needs of seniors. Frenkel’s exercises fulfil this condition due to simplicity and usefulness in practice.

The arguments stated above are those that prove the value and ergonomic benefits of motion exercises offered by H.S. Frenkel. However, the strongest advantage of this treatment offer originating from the 19th century is its actuality.

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