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# Generalized Net Model of Physical Examination of Patient with Musculoskeletal Complaints in Kinesitherapy

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**Abstract:** A physical examination in kinesytherapy is the process by which a professional in the field investigates the body of a patient for signs of functional and pathokinesiological changes. The goal of the musculoskeletal evaluation in kinesitherapy is to determine the nature of the underlying causes of the patient complaints in order to confirm the clinical diagnosis, predict the rehabilitation potential and to choose the appropriate therapy. In the present paper we introduce a Generalized net model which delineates the overall logic of the process of physical examination and musculoskeletal evaluation in kinesitherapy and to differentiate specific structures involved in the pathologic processes.
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## 1 Introduction

Musculoskeletal complaints are among the most common problems in clinical medicine. These complaints are a major cause of limitations in daily activities, health care usage and work disability. Typically around 50% of

the population report musculoskeletal pain at one or more sites for at least one week in the last month. [6]. Musculoskeletal problems can broadly be categorized as regional or generalized, although there is often considerable overlap between these two categories. The most important part of the evaluation of a patient with musculoskeletal complaints is the physical examination. The process of physical examination in kinesitherapy is usually divided into several sections: clinical anamnesis, inspection, palpation, range of motion, muscle testing, sensation testing, reflex testing, special tests and overall dynamic motion of the body segments. Clinical anamnesis or the patient history forms the basis of the working diagnosis. The history provides the subjective data that will direct the physical examination. The initial goal is to determine whether the complaint is acute or chronic. In patient with acute injuries, the manner in which the accident occurred can provide sufficient information for the present illness. Chronic complaints usually require an extensive review of the past medical records. After the history is taken the physical examination starts with a visual inspection of the patient posture and gait. The two sides of the body should be observed for symmetry in contour and size, and any differences measured. Atrophy, masses, deformities, swelling, and skin color changes should be noted. The origin of a pain symptom and changes of the body temperature may be localized by palpation of the various anatomic structures. Palpation of the bones may determine their discontinuity in fracture assessment. Palpation of masses and swelling for consistency can distinguish between bony masses, edema, and joint effusion. To determine the presence of a muscle spasm, muscle palpation with the patient at rest will identify sustained involuntary reflex contraction resulting from pain. Valuable information is then extracted from the active and passive range of motion (ROM) examination. The active ROM provides information about the patient's willingness to move, co-ordination, level of consciousness, movements that cause or increase pain, muscle strength and ability to follow instructions and perform functional activities. Passive ROM is assessed to determine the amount of movement possible at the joint and to perceive the “end feel” at the very end of the available range of motion. The end feel for a particular joint may be the joint's normal end feel, or it may be pathological in nature. James Cyriax, specified six different end feels [3]. After the assessment of ROM has been completed it is essential to perform a manual muscle testing (MMT), to evaluate contractile units, including muscles and tendons, and their ability to generate forces. The most commonly used grading systems for MMT are those of [4, 5]. Traditionally, muscle strength has been evaluated by assigning the muscle a grade from 0 to 5. Analytical resistive testing can also

yield additional diagnostic information. In particular, reproduction of the patient's pain during resistive testing of a particular muscle suggests a diagnosis of tendinitis, muscle strain, or contusion of the muscle-tendon unit being tested. Resisted contraction of a muscle that crosses a painful joint can often elicit or exacerbate the associated joint pain. Interpretation of the specific findings during the physical examination process will permit the therapist to establish a database for the patient. This information is used to develop goals and a treatment plan. From that point of view, a certain strategy is necessary to guide physical therapists for patients with musculoskeletal complaints. The objective of this study is to present a Generalized Net model (GN-model) for physical examination approach in kinesitherapy.

## 2 Generalized Net Model of Physical Examination of Patients with Musculoskeletal Complaints in Kinesitherapy

Generalized nets (GNs; see [1]) are an apparatus for modeling of parallel and concurrent processes, developed as an extension of the concept of Petri nets and some of their modifications. The presented GN-model is the first one which represents the physical examination approach in patient with musculoskeletal complaints. In general, the GNs may or may not have some of the components in their definition. GNs which do not have some of the components form special classes called reduced GNs ([2]). Here is represented a reduced GN-model of physical examination in kinesitherapy. The proposed model (Fig. 1) has 32 places and the following set of transitions:

$$A = \{Z_1, Z_2, Z_3, Z_4, Z_5, Z_6, Z_7, Z_8\}$$

These transitions describe the following processes:

- $Z_1$ represents the personal record (data) of the patient,
- $Z_2$ – the history and current symptoms of the patient,
- $Z_3$ – the results from the initial examination,
- $Z_4$ – the results from the active movements of the patient,
- $Z_5$ – the results from the passive movements of the patient,
- $Z_6$ – the results from the MMT,
- $Z_7$ – interpretation of the results from the physical examination of the patient,
- $Z_8$ – the possible diagnosis and the cause of symptoms of the patient.

The GN-model contains 10 types of tokens: $\alpha$, $\beta$, $\mu$, $\eta$, $\gamma$, $\delta$, $\varepsilon$, $\pi$, $\nu$ and $\kappa$. At the time of duration of the GN-functioning, some of these tokens can split, generating new tokens, that will transfer in the net obtaining respective characteristics, and also in some moments they will unite with some of tokens $\alpha$, $\beta$, $\mu$, $\eta$, $\gamma$, $\delta$, $\varepsilon$, $\pi$, $\nu$ and $\kappa$. Some of the model transitions contain the so called "special place" where a token stays permanently and collects information about the specific parts of the physical examination process which it represents as follows:

- In place $l_3$, token $\beta$ stays permanently and collects the overall information obtained from the physical examination in the medical record of the patient,
- In place $l_8$, token $\mu$ stays permanently and collects information about the medical history, inspection and palpation of the patient,
- In place $l_{11}$, token $\eta$ stays permanently and collects information about the results from the examination of the non-affected body segments of the patient,
- In place $l_{12}$, token $\gamma$ stays permanently and collects the information obtained from the examination of the active ROM of the patient,
- In place $l_{16}$, token $\delta$ stays permanently and collects the information obtained from the examination of the passive ROM of the patient,
- In place $l_{19}$, token $\varepsilon$ stays permanently and collects the information obtained from the examination of the MMT of the patient,
- In place $l_{27}$, token $\pi$ stays permanently and collects the information obtained during the interpretation of the results from the physical examination,
- In place $l_{30}$, token $\nu$ stays permanently and collects the information from the special tests,
- In place $l_{31}$, token $\kappa$ stays permanently and collects the information from the overall results of the physical examination of the patient.

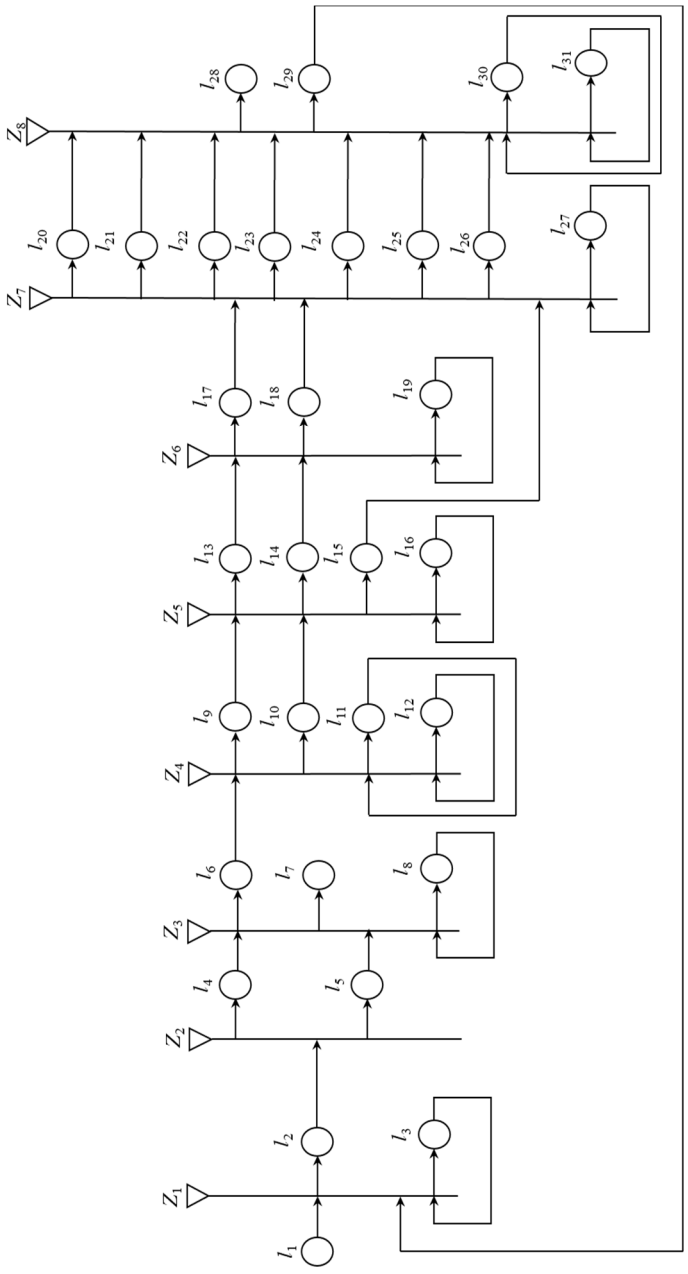


Figure 1. GN-model of physical examination of a patient with musculoskeletal complaints

During the GN-model functioning, the $\alpha$-tokens will unite with the tokens from the rest types ($\beta$, $\mu$, $\eta$, $\gamma$, $\delta$, $\varepsilon$, $\pi$, $\nu$ and $\kappa$). After that, some of these tokens can split in order to generate new α-tokens obtaining corresponding characteristics.

Token $\alpha$ enters the net with initial characteristic "*patient with musculo-skeletal complaints*" in place $l_1$. The transitions of the GN-model have the following forms:

$$Z_1 = \langle \{l_1, l_3, l_{29},\}, \{l_2, l_3,\}, r_1 \rangle,$$

where:

$$r_1 = \begin{array}{c|cc} & l_2 & l_3 \\ \hline l_1 & false & true \\ l_3 & true & true \\ l_{29} & false & true \end{array}$$

The tokens from the three input places of transition $Z_1$ enter place $l_3$ and unite with token $\beta$ with the above mentioned characteristic. On the next time-moment, token $\beta$ splits to two tokens – the same token $\beta$ and token $\alpha_1$. Token $\alpha_1$ enters place $l_2$ and there it obtains a characteristic:

"*perform a detailed medical history and the initial physical examination*".

The transition $Z_2$ has the following form:

$$Z_2 = \langle \{l_2\}, \{l_4, l_5\}, r_2 \rangle,$$

where:

$$r_2 = \begin{array}{c|cc} & l_4 & l_5 \\ \hline l_2 & W_{2,4} & W_{2,5} \end{array}$$

and,

- $W_{2,4}$ = *"patient with previous history of traumatic events or acute injury"*,
- $W_{2,5} = \neg W_{2,4}$.

When the predicate $W_{2,4}$ is true, token $\alpha_1$ enters place $l_4$ and there it obtains a characteristic:

"*consider fracture, dislocation, subluxation, contusion or soft tissue lesions: perform an initial examination*".

When the predicate $W_{2,5}$ is true, token $\alpha_1$ enters place $l_5$ and there it obtains a characteristic:

"*consider degenerative joint diseases, repetitive stress conditions, inflammatory diseases, muscle imbalance, autoimmune diseases, genetic diseases, soft tissues disorders or different syndromes: perform an initial examination*".

The transition $Z_3$ has the following form:

$$Z_3 = \langle \{l_4, l_5, l_8\}, \{l_6, l_7, l_8\}, r_3 \rangle,$$

where:

$$r_3 = \begin{array}{c|ccc} & l_6 & l_7 & l_8 \\ \hline l_4 & false & false & true \\ l_5 & false & false & true \\ l_8 & W_{8,6} & W_{8,7} & true \end{array}$$

and,

- $W_{8,6}$ = *"the patient has medical record with clinical diagnosis and diagnostic imaging report* $\wedge$ *the information from the history of the patient and the findings from the inspection suggests: high probabilitie of having musculoskeletal disorder"*,
- $W_{8,7} = \neg W_{8,6} \vee$ "*there are severe continues pain, severe muscle spasms, neurological disorders*"

The tokens from the three input places of transition $Z_3$ enter place $l_8$ and unite with token $\eta$ with the above mentioned characteristic. On the next time-moment, token $\eta$ splits to two tokens – the same token $\eta$ and token $\alpha_1$.

When the predicate $W_{8,6}$ is true, token $\alpha_1$ enters place $l_6$ and there it obtains a characteristic:

"*perform functional examination of the spinal cord and extremities*".

When the predicate $W_{8,7}$ is true, token $\alpha_1$ enters place $l_7$ and there it obtains a characteristic:

"*consider the presents of "red flags": send patient for medical consultation*".

The transition $Z_4$ has the following form:

$$Z_4 = \langle \{l_6, l_{11}, l_{12}\}, \{l_9, l_{10}, l_{11}, l_{12}\}, r_4 \rangle,$$

where:

$$r_4 = \begin{array}{c|cccc} & l_9 & l_{10} & l_{11} & l_{12} \\ \hline l_6 & false & false & false & true \\ l_{11} & false & false & true & false \\ l_{12} & W_{12,9} & W_{12,10} & W_{12,11} & true \end{array}$$

and,

- $W_{12,9}$ = *"there are differences in active ROM of the extremities"*,
- $W_{12,10} = \neg W_{12,9}$ ,
- $W_{12,11}$ = *"there are functional limitations in the spinal movements"*.

The tokens from the three input places of transition $Z_4$ enter place $l_{12}$ and unite with token $\gamma$ with the above mentioned characteristic. On the next time-moment, token $\gamma$ splits to three tokens – the same token $\gamma$ and tokens $\alpha_1$, $\alpha_2$.

When the predicate $W_{12,9}$ is true, token $\alpha_1$ enters place $l_9$ and there it obtains a characteristic:

"*perform a passive ROM examination*".

When the predicate $W_{12,10}$ is true, token $\alpha_1$ enters place $l_{10}$ and there it obtains a characteristic:

"*perform compression and traction provocative tests*".

When the predicate $W_{12,11}$ is true, token $\alpha_2$ enters place $l_{11}$ and there it obtains a characteristic:

"*perform special spinal exam"*

The transition $Z_5$ has the following form:

$$Z_5 = \langle \{l_9\ l_{10}, l_{16}\}, \{l_{13}, l_{14}, l_{15}, l_{16}\}, r_5 \rangle,$$

where:

$$r_5 = \begin{array}{c|cccc} & l_{13} & l_{14} & l_{15} & l_{16} \\ \hline l_9 & false & false & false & true \\ l_{10} & false & false & false & true \\ l_{16} & W_{16,13} & W_{16,14} & W_{16,15} & true \end{array}$$

and,

- $W_{16,13}$ = "*during the passive ROM examination, the end feel is normal*",
- $W_{16,14} = \neg W_{16,13}$,
- $W_{16,15} = \neg W_{16,13} \vee$ "*during the passive ROM examination the patient feels severe pain*".

The tokens from the three input places of transition $Z_5$ enter place $l_{16}$ and unite with token $\gamma$ with the above mentioned characteristic. On the next time-moment, token $\gamma$ splits to three tokens – the same token $\gamma$ and tokens $\alpha_1$, $\alpha_2$. When the predicate $W_{16,13}$ is true, token $\alpha_1$ enters place $l_{13}$ and there it obtains a characteristic:

"*perform a MMT examination*".

When the predicate $W_{16,14}$ is true, token $\alpha_1$ enters place $l_{14}$ and there it obtains a characteristic:

"*evaluate the presence of pain with resistive testing and perform a MMT examination*".

When the predicate $W_{12,15}$ is true, token $\alpha_2$ enters place $l_{15}$ and there it obtains a characteristic:

"*skip the MMT examination*".

The transition $Z_6$ has the following form:

$$Z_6 = \langle \{l_{13}, l_{14}, l_{19}\}, \{l_{17}, l_{18}, l_{19}\}, r_6 \rangle,$$

where:

$r_6 =$

| | $l_{17}$ | $l_{18}$ | $l_{19}$ |
|---|---|---|---|
| $l_{13}$ | *false* | *false* | *true* |
| $l_{14}$ | *false* | *false* | *true* |
| $l_{19}$ | $W_{19,17}$ | $W_{19,18}$ | *true* |

and,

- $W_{19,17}$ = "*the score from the MMT is from 0 to 3*",
- $W_{19,18}$ = "*the score from the MMT is from 3 to 5*".

The tokens from the three input places of transition $Z_6$ enter place $l_{19}$ and unite with token $\varepsilon$ with the above mentioned characteristic. On the next time-moment, token $\gamma$ splits to two tokens – the same token $\varepsilon$ and token $\alpha_1$.

When the predicate $W_{19,17}$ is true, token $\alpha_1$ enters place $l_{17}$ and there it obtains a characteristic:

"*consider that the patient is with weak contractile structures*".

When the predicate $W_{19,18}$ is true, token $\alpha_1$ enters place $l_{18}$ and there it obtains a characteristic:

"*consider that the patient is with strong contractile structures*".

The transition $Z_7$ has the following form:

$$Z_7 = \langle \{l_{17}, l_{18}, l_{27}\}, \{l_{20}, l_{21}, l_{22}, l_{23}, l_{24}, l_{25}, l_{26}, l_{27}\}, r_7 \rangle,$$

where:

$r_7 =$

| | $l_{20}$ | $l_{21}$ | $l_{22}$ | $l_{23}$ | $l_{24}$ | $l_{25}$ | $l_{26}$ | $l_{27}$ |
|---|---|---|---|---|---|---|---|---|
| $l_{17}$ | *false* | *false* | *false* | *false* | *false* | *false* | *false* | *true* |
| $l_{18}$ | *false* | *false* | *false* | *false* | *false* | *false* | *false* | *true* |
| $l_{27}$ | $W_{27,20}$ | $W_{27,21}$ | $W_{27,22}$ | $W_{27,23}$ | $W_{27,24}$ | $W_{27,25}$ | $W_{27,26}$ | *true* |

and,

- $W_{27,20}$ = *"the abnormal end feel is "bone to bone" or "empty end feel""*,
- $W_{27,21}$ = *"the abnormal end feel is "muscle spasm" or "leathery end feel""*,
- $W_{27,22}$ = *"the abnormal end feel is "soft end feel" or "springy block end feel""*,
- $W_{27,23}$ = *"there is strong and pain-free ROM"*,
- $W_{27,24}$ = *"there is strong and painful ROM"*.
- $W_{27,25}$ = *"there is weak and pain-free ROM"*.
- $W_{27,26}$ = *"there is weak and pain-free ROM"*.

The tokens from the all input places of transition $Z_7$ enter place $l_{27}$ and unite with token $\pi$ with the above mentioned characteristic. On the next time-

moment, token $\pi$ splits to eight tokens – the same token $\pi$ and tokens $\alpha_1$, $\alpha_2$, $\alpha_3$, $\alpha_4$, $\alpha_5$, $\alpha_6$ and $\alpha_7$.

When the predicate $W_{27,20}$ is true, token $\alpha_1$ enters place $l_{20}$ and there it obtains a characteristic:

"*consider degenerative joint disease, osteophytes, chondromalacia, joint mal-union or bursitis and joint inflammation"*.

When the predicate $W_{27,21}$ is true, token $\alpha_1$ enters place $l_{21}$ and there it obtains a characteristic:

"*consider reflexive muscle guarding or capsular disorders"*.

When the predicate $W_{27,22}$ is true, token $\alpha_1$ enters place $l_{22}$ and there it obtains a characteristic:

"*consider loose cartilage, soft tissue edema, synovitis, ligamentous tear"*.

When the predicate $W_{27,23}$ is true, token $\alpha_1$ enters place $l_{23}$ and there it obtains a characteristic:

"*consider no lesion in the contractile tissues"*.

When the predicate $W_{27,24}$ is true, token $\alpha_1$ enters place $l_{24}$ and there it obtains a characteristic:

"*consider lesion in the contractile tissues"*.

When the predicate $W_{27,25}$ is true, token $\alpha_1$ enters place $l_{25}$ and there it obtains a characteristic:

"*consider neurological disorder or complete muscle rupture"*.

When the predicate $W_{27,26}$ is true, token $\alpha_1$ enters place $l_{26}$ and there it obtains a characteristic:

"*consider severe joint or soft tissue disorder"*.

The transition $Z_8$ has the following form:

$$Z_8 = \langle \{l_{20}, l_{21}, l_{22}, l_{23}, l_{24}, l_{25}, l_{26}, l_{30}, l_{31}\}, \{l_{28}, l_{29}, l_{30}, l_{31}\}, r_8 \rangle,$$

where:

$r_8 =$

| | $l_{28}$ | $l_{29}$ | $l_{30}$ | $l_{31}$ |
|---|---|---|---|---|
| $l_{20}$ | *false* | *false* | *false* | *true* |
| $l_{21}$ | *false* | *false* | *false* | *true* |
| $l_{22}$ | *false* | *false* | *false* | *true* |
| $l_{23}$ | *false* | *false* | *false* | *true* |
| $l_{24}$ | *false* | *false* | *false* | *true* |
| $l_{25}$ | *false* | *false* | *false* | *true* |
| $l_{26}$ | *false* | *false* | *false* | *true* |
| $l_{30}$ | *false* | $W_{30,29}$ | *false* | *true* |
| $l_{31}$ | $W_{31,28}$ | *false* | $W_{31,30}$ | *true* |

and,

- $W_{31,28}$ = *"the results from the physical examination confirms: the initial clinical diagnosis and the cause of the patient complaints"*,
- $W_{31,30} = \neg W_{31,28}$,
- $W_{30,29}$ = *"the results from the special tests confirms: the initial clinical diagnosis and the cause of the patient complaints"*,

The tokens from the three input places of transition $Z_8$ enter place $l_{31}$ and unite with token ν with the above mentioned characteristic. On the next time-moment, token κ splits to three tokens – the same token $\kappa$ and tokens $\alpha_1$ and $\alpha_2$. When the predicate $W_{31,28}$ is true, token $\alpha_1$ enters place $l_{28}$ and there it obtains a characteristic:

"*establish a database for the patient and choose the appropriate rehabilitation program*".

When the predicate $W_{31,30}$ is true, token $\alpha_2$ enters place $l_{30}$ and unites with token κ. On the next time-moment, token κ splits to two tokens – the same token κ and token $\alpha_1$ which obtains a characteristic:

"*perform additional specific tests*".

When the predicate $W_{30,29}$ is true, token $\alpha_2$ enters place $l_{29}$ and there it obtains a characteristic:

"*establish a database for the patient and choose the appropriate rehabilitation program"*.

On the next time moment the same token from the place $l_{29}$ goes to place $l_3$ to extend the personal record of the patient.

## 3 Conclusion

The so described GN-model may provide a framework that can be used by physical therapists to guide physical examination approach to patient with musculoskeletal complaints, enabling more accurate and efficient identification of potential causes and would assist in optimizing patient outcomes and more effective treatment and rehabilitation.

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