USING THE ERGOSCOPE WORK SIMULATOR AND ICF IN INSURANCE MEDICINE AND OCCUPATIONAL HEALTH

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SUMMARY

Objectives: Instrumental work diagnostic examinations can be used for capability assessment in evaluating work suitability, job selection, complex and occupational rehabilitation, and career counselling. According to the literature, assessments performed with work simulators and the International Classification of Functioning, Disability and Health (ICF) are suitable for monitoring changes in functional capacity. We propose that instrumental work diagnostic measurements – specifically, measurements conducted on the ErgoScope work simulator – along with the ICF, can be effectively used for the objective assessment of functional capacity and tracking changes over time.

Methods: At the request of an insurance company, a targeted examination was performed using the ErgoScope work simulator to determine the extent of force exertion. The measurement plan, evaluation of results, and ICF coding were prepared based on a methodology developed in our previous research with qualified assessors.

Results: The measurement results were recorded in an examination report. The examined individual was able to complete all tasks. If there was a difference in exertion between the two hands, the right hand/arm was always weaker.

Conclusion: Based on our experience, determining ICF qualifiers requires not only measurement data but also precise, documented observations from the examiner. Our study suggests that the measurement results obtained from ErgoScope work simulator examinations, along with ICF categories assigned by qualified assessors, are suitable for tracking changes in functional capacity. This methodology supports medical professionals in insurance medicine and occupational health services in making objective, data-driven decisions.

Key words: functional health, ICF, insurance medicine, occupational health, work ability

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https://doi.org/10.21101/cejph.a8591

INTRODUCTION

The restructuring of the labour market, as well as changes in functional capacity due to illness or accidents, often necessitate job changes, career shifts, or learning a new profession. The employment rate of both individuals with and without disabilities increases with the level of education attained (1). For effective work performance and to prevent career dropouts, it is crucial that individuals – with and without disabilities – pursue professions that align with their abilities and health conditions. This can be achieved through instrumental ability assessments, work diagnostic examinations, work capacity evaluations, career counselling, and occupational rehabilitation measures. These tasks are most frequently encountered by professionals working in occupational health and insurance medicine.

Work diagnostic examinations can be conducted in various situations, such as assessing suitability for high-risk jobs, selecting candidates for specific positions, evaluating individuals before complex rehabilitation, conducting follow-ups, and providing career suitability and orientation counselling (1, 2). These examinations can be performed as general assessments or according to targeted measurement plans focusing on specific abilities. These targeted assessments are useful for return-to-work (RTW) evaluations, occupational rehabilitation, fitness assessments, and assessing the consequences of permanent impairments due to accidents or illnesses. Work diagnostic examinations can be also used to track changes in functional capacity over time. A Lithuanian research group measured the performance of vocational trainees using the ERGOS II work simulator before and after a three-month individualized rehabilitation and development programme. The results highlighted clear improvements in dynamic strength exertion and reaction times (3).

A specialized ability for a particular work activity may enable or even guarantee successful task completion, “aptitude” or “suitability” merely indicates a likelihood of success in the future. Success in a job refers to the realized suitability: the sustained, successful performance of a specific activity in a real work environment (successful career realization).

To carry out work diagnostic examinations, we can use ability tests, various questionnaires, work sample tests, and instrumental assessments. Work psychological instruments can measure specific abilities through the use of “work sample tests”, work simulators, and task series that assess movements and multiple abilities during a single examination. Work sample tests are the most accurate means of predicting success in workplace tasks and performance (4, 5). This strongly supports the use of objective measurement tools and work simulators that operate based on the work sample test principles. The advantage of work sample tests lies in their reliability and content validity, as the tasks to be completed are similar to actual job duties, and the results are difficult to falsify (6). However, the two major drawbacks of work sample tests are that they are costly and time-consuming. Despite these disadvantages, the use of work sample tests proves worthwhile, especially for high-risk jobs, where mistakes or accidents during work could result in significant damage. According to international literature, the most commonly used work simulators for job suitability assessments are the ERGOS work simulator, Blankenship FCE system, Ergo Kit, Valpar Work Samples, Isenhagen Work System, Metriks Education, Baltimore Therapeutic Equipment (BTE) (7, 8), the NOF system developed in Poland (9, 10), and the Hungarian ErgoScope work simulator (2).

The ErgoScope stationary work simulator developed in Hungary aligns with the simulated work tasks due to functional and psychological realism (11, 12). The ErgoScope consists of three panels (panel 0, panel 1, panel 2) and can perform 36 tasks or work processes, measuring 203 specific abilities (13). On the panel 0, dynamic and static force exertion can be tested (e.g., pushing, pulling horizontally, vertically, or lifting to seat height) (Fig. 1). The panel 1 allows tasks to be performed while seated, such as wrist gripping, finger gripping, tactile tasks, and using a keyboard with one or both hands, or using a pencil. On the panel 2 tasks must be performed while standing. This panel assesses eye-hand coordination, attention, complex tasks, tolerance for monotony, and work endurance (e.g., adjusting switches in a sequence, quickly operating push-buttons, completing tasks in the correct order, sorting, organizing, and performing tasks at a fast pace).

A good example of using instrumental work diagnostic assessments in career counselling is the Piarist Outlook Centre established in 2018 in Vác. Its main focus is career counselling. The counselling services include questionnaire surveys, psychological and special education assessments, developments, and instrumental work diagnostic examinations (14, 15). The work diagnostic methodology and measurement protocol developed by the Piarist Outlook Centre are also applicable for career changes in adulthood or after returning to work (RTW) and switching job positions (14).

Before the commissioning of the ErgoScope work simulators, the manufacturing company and the National Rehabilitation and

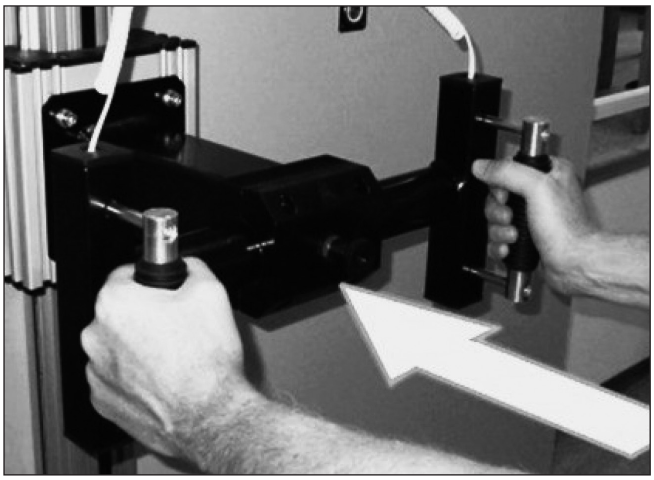

Fig. 1. ErgoScope – panel 0, static pressure horizontally with two hands (2).

Expert Institute conducted research within the framework of a project to establish reference values. The reference values for the measurable parameters were determined based on the measurement database and categorized into three value ranges (16) (Table 1). This method ensures that performance levels can be assessed and categorized accordingly based on reference percentiles.

The evaluation of the results from the ErgoScope work simulator and the use of these results led to an exploration of the potential connection between the ErgoScope measurement outcomes and the International Classification of Functioning, Disability and Health (ICF) framework (17). While initially complex, the ICF becomes routine and practical after some practice, especially when using pre-prepared condition-specific core sets and checklists. This classification can be very useful for integrating functional assessment results, such as those obtained from the ErgoScope, into broader healthcare and rehabilitation settings.

The research results of several research groups testing the ICF classification system have highlighted the usefulness of the ICF framework in rehabilitation, as it allows for the precise formulation of needs and the clear tracking of changes over time, and the ICF can also be used to assess dynamic changes (18–20). A Dutch research group focused on the ICF application in occupational health. They collected work-related environmental factors and compared them with environmental factors from the ICF. They identified 53 factors, of which 30 supported return-to-work and 23 hindered it. This research group also adapted a diagram to illustrate the interactions between the ICF components in the context of work (21).

In the National Centre for Public Health and Pharmacy (NCPHP)s' Occupational Health Department, an analysis of 272 second-degree occupational medical fitness assessments was conducted from 2019 to March 2021. The analysis focused on factors that limited job performance, such as functional impairments and health conditions that affected one's ability to perform work duties. In 29 cases, instrumental work diagnostic tests would have helped clarify limitations and would have supported more precise judgments on suitability for work. In one case, it is likely that a different decision would have been made if an ErgoScope work simulator test had been available. The health conditions that justified using instrumental work diagnostic tests included paralysis from stroke, upper limb involvement from multiple sclerosis, amputation due to hand injury, vision loss after head trauma, finger contractures, memory impairment after brain infarction, shoulder injuries, and progressive neurological diseases with musculoskeletal symptoms (22).

Based on the literature review of instrumental work diagnostic examinations and ICF classification, our goal was to test the ErgoScope work simulator examination protocol and the methodology for coding the measurement results according to ICF in a real-world, non-experimental setting. The ErgoScope-ICF methodology was modified as needed based on the experiences gained during its use. Our experiences will be shared through this study.

MATERIALS AND METHODS

The ErgoScope work simulator examination was conducted at the request of the insurance company, with the aim of determining the employee's capacity for exertion. The subject gave written consent for the use of the measurement results for scientific and publication purposes. The subject had sustained a right shoulder injury (bone fracture) in a car accident, resulting in permanent health impairment.

After the shoulder fracture, the subject has limited use of the right upper limb. Due to pain, the subject is unable to perform twisting motions with the arm, experiences sharp pain in the right shoulder under heavier physical strain, and the right elbow occasionally hurts. When lifting objects heavier than 15 kg, they often drop. The subject worked as a warehouse worker and materials handling machine operator before and after the accident. Currently, she feels that due to the restricted movement of the right shoulder, she cannot fully perform her tasks.

The examination of functional capacity and exertion level was performed using the Hungarian-made ErgoScope work simulator. Before the measurement, a medical history interview and general health assessment were conducted. None of the tasks in the examination plan were contraindicated due to health conditions. The tasks were performed over a period of 75 minutes. The measurement protocol and form were developed based on experiences gained during our research at the Piarist Outlook Centre. Accordingly, the tasks to be performed/measured on the ErgoScope work simulator for the subject were as follows:

Panel 0, two-handed exertion:
- Static pressure horizontal average (N)
- Static pull horizontal average (N)
- Static pressure vertical average (N)
- Static pull vertical average (N)
- Dynamic lifting performance to seat height (Nm/s)
- Dynamic load capacity (kg)

Panel 1, one-handed exertion, touch, fine motor skills:
- Grip strength average (N)
- Key pinch strength average (N)
- Three-point pinch strength average (N)
- Wrist flexion average (N)

Panel 2, attention, motivation, endurance:
- Average cycle time (s)

Based on the previously conducted second-level work medical suitability examinations, documentation review, subsequent ICF coding of health changes, the following ICF classifications were used for the measured functional abilities:

Physical capacities:
- Static load and posture:
  - Standing d 4154
  - Seating d 4103
- Dynamic load:
  - Manual material handling (carrying) d 4301
  - Lifting to table height d 4300
  - Bending d 4105
  - Squatting d 4101
  - Walking d 4500, d 4501
  - Pulling d 4450
  - Pushing d 4451
- Fine motor skills, sensorimotor performance:
  - Pinch grip d 4400
  - Grip with hand, arm-hand stability d 4401
  - Coordination b 7602
  - Wrist rotation, hand and arm rotation, twisting d 4453

The qualifiers of the ICF categories (Table 2) were determined by considering the percentage distribution of the ICF value ranges described by the World Health Organization (WHO) and the value ranges created during the development of the ErgoScope reference values (Table 1) (23).

RESULTS

The precise measurement results can be found in the measurement protocol and the explanations are as follows:

Static force measurements (P50–P80 Hungarian female average; higher value indicates better performance):

- Static pressure horizontal (average N): 43N (43–67N) average performance. The first and last (fourth) exertions were stronger with the left hand.
- Static pull horizontal (average N): 33.04N (42–70N) below average performance. During the first exertion, both hands applied equal force, but during the next three exertions, the left

Table 1. *Three ranges for reference values of ErgoScope work simulator*

For parameters in "lower value = better performance" category (e.g., reaction time, number of errors)			For parameters in "higher value = better performance" category (e.g., number of correct answers, degree of muscle exertion)		
Values of parameter X within specified percentile range		Evaluation	Values of parameter X within specified percentile range		Evaluation
1st range	X < P20 (X values less than P20)	Good performance – suitable for the job	3rd range	X < P50 (X values less than P50)	Below average performance – unsuitable for the job or suitable for only part of the job
2nd range	P20 ≤ X ≤ P50 (X values between P20 and P50, including the boundaries)	Acceptable performance – suitable for the job with restrictions (e.g., part-time)	2nd range	P20 ≤ X ≤ P50 (X values between P20 and P50, including the boundaries)	Acceptable performance – suitable for the job with restrictions (e.g., part-time)
3rd range	P50 < X (X values greater than P50)	Below average performance – unsuitable for the job or suitable for only part of the job	1st range	P80 < X (X values greater than P80)	Good performance – suitable for the job

P – percentile

Table 2. *Converting values measured on ErgoScope work simulator to ICF qualifiers*

ICF qualifiers	4	3	2	1		0		
Percentage of problem occurrence by ICF	96%–100%	50%–95%	25%–49%	5%–24%		0%–4%		
Percentile of values measured on ErgoScope	The person examined is unable to perform the task.	P50 below	P50 below	P50 below	P50–P80	P50–P80	P80 above	**Higher value = better performance**
		P50 above	P50 above	P50 above	P20–P50	P20–P50	P20 below	**Lower value = better performance**
Three ranges of reference values for ErgoScope work simulator	3rd range Below average performance – unsuitable for the job or suitable for only part of the job				2nd range Acceptable performance – suitable for the job with restrictions (e.g., part-time or with limited manual handling)		1st range Good performance – suitable for the job	
Observation of examination leader during measurement on ErgoScope		While performing a task, he/she has a significant complaint, reports pain, which makes it difficult to perform the task. In addition, he/she may feel tired, his/her performance may be declining or very unsteady	Tired while performing a task, with a downward trend or very unsteady performance	No complaints, no fatigue, no decrease in performance during the task, yet worse results were measured	Tired while performing a task, with a downward trend or very unsteady performance, yet better results were measured	No complaints, no fatigue, no decrease in performance during the task		

P – percentile

hand produced more force. No noticeable fatigue was observed in either hand.

- Static pressure vertical (average N): 57.23N (62–74N) below average performance. Throughout the test, significantly greater force was exerted with the left hand. During the first exertion, the right hand exerted similar force to the left, but this rapidly decreased, and the level remained low for the rest of the exertions.
- Static pull vertical (average N): 59.5N (94–121N) below average performance. A significant difference between the two hands was observed during the first and fourth exertions. Throughout all four exertions, more force was exerted with the left hand.

Calculation based on the average value of both hands.

Dynamic force measurements (P50–P80 Hungarian female average; higher value indicates better performance):

- Dynamic lift to chair height (performance Nm/s): 8.16 Nm/s (8.6–9.7 Nm/s) below average performance.
- Dynamic load capacity (kg): 6.24 kg (5.5–6.3 kg) average performance.

Grip force measurements (P50–P80 Hungarian female average; higher value indicates better performance):

Grip strength (average N):

- Left hand: 72.02N (73–85N) below average performance.
- Right hand: 37.54N (84–101N) below average performance. A significant difference in exertion between the two hands was observed, and this difference was fairly consistent throughout the task.

Key pinch (average N):

- Left hand: 23.41N (26–31N) below average performance.
- Right hand: 12.06N (27–32N) below average performance. The right hand's performance was weaker throughout, with very fluctuating force exertion.

Three-point pinch (average N):

- Left hand: 22.36N (21–27N) average performance. The force exertion curve remained nearly consistent.
- Right hand: 14.32N (22–30N) below average performance. The exertion curve was initially fluctuating and later became slightly fluctuating.

Wrist flexion (average N):

- Left: grip strength could not be measured.
- Right: grip strength could not be measured.

Work endurance (P50–P20 Hungarian female average; lower value indicates better performance):

Table 3. *Explanation of values measured on ErgoScope work simulator with ICF coding*

<table>
<tr><th>Functional ability</th><th>ICF with qualifier</th><th colspan="2">Additional explanation</th></tr>
<tr><td>Standing position</td><td>d 4154.0</td><td colspan="2">Average functional capacity</td></tr>
<tr><td>Sitting position</td><td>d 4103.0</td><td colspan="2">Average functional capacity</td></tr>
<tr><td>Manual handling, carrying in both hands</td><td>d 4301.1</td><td colspan="2">Below average dynamic effort, but minimally below average; dynamic load capacity was average (max. lifted weight in kg)</td></tr>
<tr><td>Lifting to table height</td><td>d 4300.1</td><td colspan="2">Below average dynamic effort, but minimally below average; dynamic load capacity was average (max. lifted weight in kg)</td></tr>
<tr><td>Bending</td><td>d 4105.1</td><td colspan="2">She was complaining during the ball retrieval, but managed to complete the task</td></tr>
<tr><td>Squatting</td><td>d 4101.1</td><td colspan="2">She was complaining during the working endurance, but managed to complete the task</td></tr>
<tr><td>Walking, short walking</td><td>d 4500.0</td><td colspan="2">Average functional capacity</td></tr>
<tr><td>Pulling right hand</td><td>d 4450.2</td><td colspan="2" rowspan="2">During the static vertical pulling, the force exerted by the right hand was greater than that of the left hand, than during the static horizontal pulling</td></tr>
<tr><td>Pulling left hand</td><td>d 4450.2</td></tr>
<tr><td>Pulling both hands</td><td>d 4450.2</td><td colspan="2">Below average performance</td></tr>
<tr><td>Pushing right hand</td><td>d 4451.2</td><td colspan="2" rowspan="2">During the static vertical pushing, the effort of the right hand was more than the effort of the left hand during the static horizontal pushing</td></tr>
<tr><td>Pushing left hand</td><td>d 4451.1</td></tr>
<tr><td>Pushing both hands</td><td>d 4451.1</td><td colspan="2">Static pushing is average performance horizontally; vertical pushing is below average performance</td></tr>
<tr><td>Hand grip, hand, arm stability</td><td></td><td colspan="2"></td></tr>
<tr><td>3-point grip with finger – right hand</td><td>d 4401.1</td><td colspan="2">With the right hand, the force power curve is undulating</td></tr>
<tr><td>3-point grip with finger – left hand</td><td>d 4401.0</td><td colspan="2">Average functional capacity</td></tr>
<tr><td>Key grip with finger – right hand</td><td>d 4401.2</td><td>The performance of the right hand is very variable throughout</td><td rowspan="2">Below average performance with both hands</td></tr>
<tr><td>Key grip with finger – left hand</td><td>d 4401.2</td><td></td></tr>
<tr><td>Grip with the right hand</td><td>d 4401.2</td><td colspan="2">Performance significantly below average</td></tr>
<tr><td>Grip with the left hand</td><td>d 4401.1</td><td colspan="2">Performance is just below average</td></tr>
<tr><td>Movement coordination</td><td>b 7602.0</td><td colspan="2">Average functional capacity</td></tr>
<tr><td>Turning or twisting the right hand</td><td>d 4453.3</td><td colspan="2" rowspan="2">Greater loss of functionality – task was done, she could not exert any measurable force with either hand</td></tr>
<tr><td>Turning or twisting the left hand</td><td>d 4453.3</td></tr>
</table>

- Work endurance (average cycle time ‘s’) for moving a 5 kg box: 52.03 s (56.7–47.7 s) average performance. Among the sub-tasks, the ball rolling time was consistent, while the box movements and ball sorting times gradually shortened over 10 cycles.

The maximum weight of the box to be lifted in the work endurance task was calculated as follows: during the static pull vertical task, the average of the two hands’ maximum force exertion for the subject (left: 122.5N, right: 99.5N) was 111N. Therefore, staMAX = 111N (11.1 kg), and 50% of 11.1 kg is 5.05 kg. Thus, the subject worked with a box weighing a maximum of 5 kg in the work trial series.

The ICF coding was prepared based on the WHO guidelines, the measurement results obtained from the ErgoScope work simulator, and the experiences from our previous research on the integration of ICF, along with the supporting materials we developed (Table 3).

DISCUSSION

The measurement/testing plan for the ErgoScope work simulation was created at the request of the examined person’s insurer to determine the “degree of exertion”. Since none of the tasks in the measurement plan were contraindicated due to health issues, the examined person completed all the tasks listed. The measurement results were evaluated based on the average values for Hungarian women (P20–P50–P80). Notably, the performance of the examined person was average in static horizontal pressure, dynamic load tolerance, three-point grip with fingers, left hand performance, and work endurance. In the execution of other tasks, the performance was below average. The examined person could not exert enough force with either hand to measure force during wrist flexion. The difference in force exertion between the two sides was clearly noticeable. In all tasks requiring force exertion, the right hand produced less force. During static vertical exertion, the right hand’s performance was significantly lower than the left, more so than in the horizontal tasks. During vertical static pressure (upward pressure), the force exerted by the right hand/arm was further reduced compared to the left, more so than during vertical static pulling (pulling from below). During the work endurance task, which was complex and consisted of several sub-tasks, the overall performance was good, and the examined person did not experience fatigue while completing the task. The cycle time for the sub-tasks gradually shortened (no fatigue was observed but due to practice/learning the task was completed more quickly by the examined person).

The measurement results and the ICF categories qualifiers indicate that the examined person’s right hand/arm is weaker, but no other functional impairments were measurable.

In this case, it would have been important to compare the test results with earlier measurement outcomes. However, any future improvements or deterioration in condition can be objectively supported by measurement data, which is significant for the insurance case.

Based on our experience, merely the measurement data is insufficient for determining the qualifiers for the ICF categories; detailed, documented observations by the examiner are also required, such as mild to severe pain during certain movements or complaints of fatigue during prolonged tasks.

CONCLUSION

The methodology described in the article regarding the combined use of instrumented work diagnostic measurements and the ICF demonstrates why it is advisable to use measurement/ICF coding together and in which areas they can be applied jointly. Work diagnostic examinations provide objective measurement data for assessing occupational fitness, conducting occupational rehabilitation, evaluating work capacity, and monitoring functionality through the examination of partial abilities and functionalities. The measurement results from tests conducted on the ErgoScope work simulator, along with the assigned ICF categories and qualifiers, are suitable for tracking changes in functionality. Even small percentage changes in objective measurement results are valuable data for the examining professional, occupational health specialist, or forensic medical expert, as they indicate the direction and extent of changes in the individual’s functionality. Depending on the rate of recovery, it may be beneficial to repeat the ErgoScope work simulation test after 1–2 years, as it is possible that the individual could return to their original job. If a forensic or insurance medical expert needs to provide an opinion on partial abilities and functionality impairments related to an injury, the joint use of the work simulator and ICF will help by providing objective data to support their work. Additionally, if the individual passes the instrumented work psychology test, they are more likely to succeed in the given role. In conclusion, it can be stated that for every employee group, including vulnerable workers, the combined ICF coding of the functionality assessed through instrumented work diagnostic tests and the workplace environment would contribute to a safer and healthier work performance.

Today, when certain economic sectors are facing labour shortages, it is crucial that every person of working age finds a job that matches their abilities. Only in this way can the distribution of labour in the labour market be optimized. Insurance-related legal cases involving permanent functional impairments after illnesses and accidents are becoming more frequent, and objective data is essential for experts to form their opinions. In the future, our goal is to use the ErgoScope work simulator and the ICF together in as many insurance medical assessments as possible, thereby further refining the methodology.

Acknowledgements
We would like to thank the Institute of Forensic and Insurance Medicine of Semmelweis University for their support in writing this article.

Conflicts of Interest
None declared

Adherence to Ethical Standards
In writing this article, anonymous data were secondarily processed, and previous publications were used. Secondary processing of the studies described in this study was performed with the subject’s permission. The work simulator measurement was not a clinical trial and did not include an intervention. This study does not require ethical approval. The work simulator measurement was performed in accordance with the Helsinki criteria and in compliance with applicable data protection safeguards.

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Received March 15, 2025
Accepted in revised form July 29, 2025